MINERAL REPORT 35

CANADIAN MINERALS YEARBOOK 1986

REVIEW AND OUTLOOK

CENTENNIAL EDITION 1886-1986

Energy, Mines and Resources Canada
Energie, Mines et Ressources Canada

Hon. Gerald S. Merrithew,
Minister of State
(Forestry and Mines)

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Foreword

This edition of the Canadian Minerals Yearbook marks the centennial of the first publication of the federal government to record annual statistics on Canada's mineral production. To underline the occasion, a selection of title pages dating back to 1886 is reproduced on the next page. It illustrates the various titles and organizations under which the Yearbook was published over the last one hundred years. A comparative table of 1886 and 1986 mineral production figures, displaying the dramatic increases in output levels of the Canadian mineral industry, is also presented.

The Government of Canada published its first comprehensive report on the country's mineral industry in 1886. While preliminary annual statistics were tabled in the Mineral Production of Canada, the final more exhaustive statistical statements appeared in a section of the Annual Report of the Geological Survey of Canada entitled Statistical Report on the Production, Value, Exports and Imports of Minerals in Canada. In 1906, the Department of Mines undertook to produce the Mineral Production of Canada. In 1921, the responsibility for this publication was transferred to the Dominion Bureau of Statistics. Subsequently, in 1922, the Department of Mines introduced a new publication, the Canadian Mineral Industry, which comprised its final annual statistical statements. It was in 1962 that the Canadian Minerals Yearbook was first published under its existing title.

The 1886 edition was also published in French. Later French editions were produced intermittently until 1950 when, except for a ten-year period between 1968-78, they were published on a regular yearly basis.

This issue reports on the activity of the mineral industry over the past year. The General Review identifies the predominant economic events of 1986 and indicates the major trends in the Canadian economy. It also covers the general developments and overall patterns of the mineral industry during the year. The 55 commodity chapters feature economic developments, uses, price, exports and production and consumption figures specific to each commodity. The Outlook section under each review provides a forecast of the industry's future position.

The basic statistics on Canadian production, trade and consumption, unless otherwise stated, were collected by the Information Systems Division, Mineral Policy Sector of Energy, Mines and Resources Canada, and by Statistics Canada. Market quotations were taken mainly from standard marketing reports. Corporate data were obtained directly from company officials through surveys or correspondence, or were extracted from annual reports. Energy, Mines and Resources Canada is grateful to all those who contributed information used in the preparation of this report.

Additional copies of the Yearbook can be purchased from the Canadian Government Publishing Centre. Reprints of individual chapters and Map 900A, Principal Mineral Areas of Canada, may be obtained free of charge from:

Publication Distribution Office
Mineral Policy Sector
Energy, Mines and Resources Canada
580 Booth Street
Ottawa, Ontario
K1A 0E4

Previous editions of the Canadian Minerals Yearbook have been deposited in various libraries across Canada.

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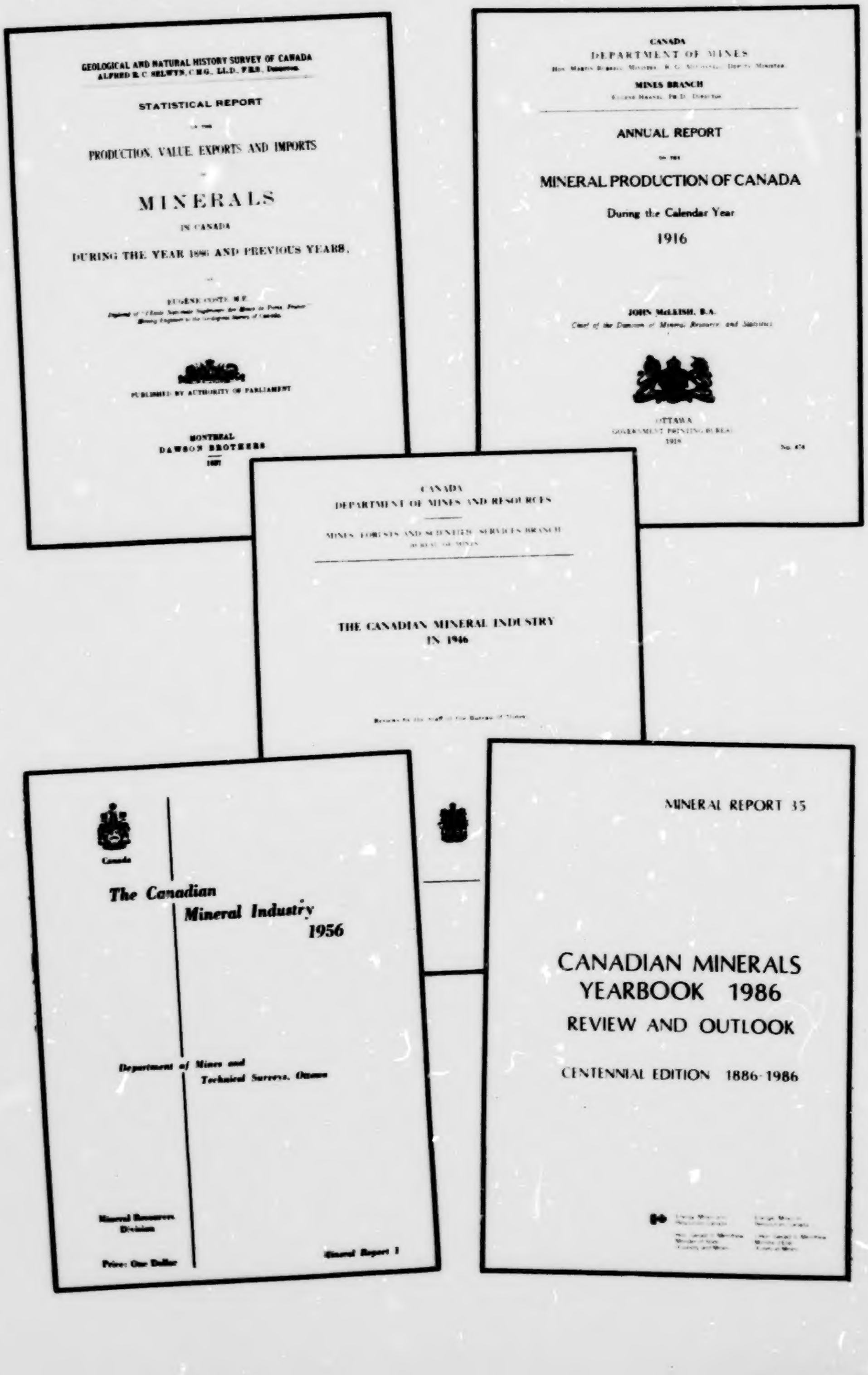
Front Cover:
View of the Sigma gold mine, located in Val-d'Or in northwestern Quebec (SSC-Photocentre-ASC).

This year, the Sigma Mine celebrates the 50th anniversary of its opening on March 17, 1937. Since operations began, the mine has produced over 108 862 kg of gold with production totalling 2 013 kg in 1986.

ONE HUNDRED YEARS OF MINERAL STATISTICS



GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., Director.

STATISTICAL REPORT

PRODUCTION, VALUE, EXPORTS AND IMPORTS

MINERALS

IN CANADA

DURING THE YEAR 1886 AND PREVIOUS YEARS,

EUGÈNE COSTE, M.E.

PUBLISHED BY AUTHORITY OF PARLIAMENT

MONTREAL
DAWSON BROTHERS
1887

CANADA
DEPARTMENT OF MINES

MINES BRANCH

ANNUAL REPORT

MINERAL PRODUCTION OF CANADA

During the Calendar Year

1916

JOHN McLEISH, B.A.
Chief of the Division of Mineral Resources and Statistics

OTTAWA
GOVERNMENT PRINTING BUREAU
1918

CANADA
DEPARTMENT OF MINES AND RESOURCES

MINES, FORESTS AND SCIENTIFIC SERVICES BRANCH
BUREAU OF MINES

THE CANADIAN MINERAL INDUSTRY
IN 1946

Reviews by the staff of the Bureau of Mines

Canada

The Canadian
Mineral Industry
1956

Department of Mines and
Technical Surveys, Ottawa

Mineral Resources
Division

Price: One Dollar

Mineral Report 1

MINERAL REPORT 35

CANADIAN MINERALS
YEARBOOK 1986
REVIEW AND OUTLOOK

CENTENNIAL EDITION 1886-1986

SUMMARY OF CANADIAN MINERAL PRODUCTION
1886 VS 1986P

	1886			1986		
	Unit	Quantity	Value[a]	Quantity (000)	Value (000)	Unit
Antimony ore	ton	665	31,490	3 900	23,910	tonne
Arsenic	ton	120	5,460	..	..	
Asbestos	ton	3 458¼	206,251	640	300,586	tonne
Barite		-	-	37	4,635	tonne
Cement		-	-	10 058	790,846	tonne
Charcoal	bush.	901 500	54,000	-	-	
Chromic iron ore	ton	60	945	-	-	
Coal	ton	2 091 976	5,017.225	57 800	1 716,000	tonne
Cobalt		-	-	2 486	56,242	kg
Coke	ton	35,396	101,940	4 536 061	..	tonne
Copper (fine, contained in ore)	lb.	3 505 000	354,000	768 244	1,567,988	kg
Gold	oz.	76 879	1.330.442	104 655	1,715,392	g
Graphite	ton	500	4.000	..	..	
Grindstones	ton	4 020	46,545	-	-	
Gypsum	ton	162 000	178,742	8 542	80,613	tonne
Iron ore	ton	69 708	126,982	36 096	1,254,758	tonne
Lead		-	-	303 503	204,427	kg
Magnesitic dolomite & brucite		-	-	144	19,165	tonne
Manganese ore	ton	1 789	41,499	-	-	
Mica	lb.	20 361	29,008	..	..	
Mineral pigments						
Baryta	ton	3 864	19,270	-	-	
Terra alba	ton	4 000	24,000	-	-	
Whiting	bbl	400	600	-	-	
Ochre	ton	350	2,350	-	-	
Molybdenum	lb.	150[c]	156	12 914	113,942	kg
Natural gas		-	-	76 365	6,743,835	000 m³
Natural gas by-products		-	-	18 906	1,825,439	m³
Nepheline syenite		-		485	20,413	tonne
Nickel		-	-	180 599	1,075 467	kg
Peat		-	-	587	74,502	tonne
Petroleum	bbl.	486 441[d]	437,797	84 964	9,719,155	m³
Phosphate	ton	20 495	304,338	-	-	
Pig iron (incomplete return)	ton	22 192	237,768	9 248 530	..	tonne
Platinum Group		-	-	8 793	..	g
Potash		-	-	6 969	579,022	tonne
Pyrites	ton	42 906	193,077	-	-	
Quartz		-	-	2 437	42,834	tonne
Salt	ton	62 359[e]	227,195	11 088	241,611	tonne
Silver		..	209,090[b]	1 219	310,102	kg
Soapstone	ton	50	400	125	15,746	tonne
Sodium sulphate		-	-	371	33,413	tonne
Structural materials						
Granite	ton	6 062	63,309	-	-	
Marble and serpentine	ton	501	9,900	-	-	
Slate	ton	5 345	64,675	91 200	426,306	tonne
Flagstones	sq. ft.	70 000	7,875	-	-	
Building-stones	cu. yd.	165 77[illegible]	642,509	-	-	
Lime	bush.	1 535 950	283,755	2 364	206,400	tonne
Sands and gravels	ton	646 552	143,641	242 548	596,603	tonne
Bricks	M	139 345	873,600	-	-	
Tiles	M	12 416	142,617	-	-	
Miscellaneous clay products		..	112,910	..	130,353	
Sulphur, elemental		-	-	6 868	627,083	tonne
Sulphur in smelter gas		-	-	760	66,983	tonne
Uranium		-	-	10 977	923,838	kg
Zinc		-	-	1 055 103	1,304,107	kg
Total			10,529,361		33,854,397[f]	

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[a] These figures give full values at the mines, quarries, etc. [b] Port Arthur district production, plus about $167,000 estimated silver contained in the copper pyrites of the Capelton district. [c] Sold mostly as cabinet specimens. Value for manufacturing purposes from 50 to 60 cents a pound. [d] Crude equivalent of the quantity of refined oils inspected. [e] In barrels of 280 lbs. = 445,421 [illegible] [f] The value indicated does not represent the total mineral production for 1986.

P Preliminary; - Nil; .. Not available.

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* The review for this commodity was not produced in 1986.

Conversion Factors

Imperial Units to Metric (SI) Units

Ounces to grams	x	28.349 523
Troy ounces to grams	x	31.103 476 8
to kilograms	x	0.031 103 476
Pounds to kilograms	x	0.453 592 37
Short tons to tonnes	x	0.907 184 74
Gallons to litres	x	4.546 09
Barrels to cubic metres	x	0.158 987 220
Cubic feet to cubic metres	x	0.028 346 85

Source: Canadian Metric Practice Guide

General Review

L. LEMAY

THE CANADIAN ECONOMY IN 1986

Moderate growth characterized the Canadian economy in 1986. Real output, measured by Gross Domestic Product grew by 3.1 per cent compared with 4.5 per cent for the previous year. This weaker performance cannot be considered disappointing, given the challenges that confronted the economic environment. Consumer spending, business investment, and export trade, the sources of growth in 1985, lost momentum throughout the year. The determination of the federal government to cut the budget deficit resulted in an increase in personal income taxes and decreased personal disposable income. Consumer spending declined to a growth rate of 3.6 per cent compared with 5.2 per cent in 1985. Business investment which increased 6.6 per cent in real terms in 1985, registered a 1.1 per cent decline in 1986. Almost all of that decline was attributable to the drop in world oil prices. The price of crude oil fell from approximately $33 per barrel on January 1, 1986 to $14.60 by mid-year. (At one point it dipped below $10). The average price for the year was $15 compared with $27 in 1985. Pre-tax corporate profits in all sectors of the economy declined for the first time since 1982 from $48 billion in 1985 to $45 billion in 1986. Net income in the oil and gas sector dropped 56 per cent. An estimated 40,000 jobs were lost in energy industries and the unemployment rate for the total economy averaged 9.3 per cent, a slight improvement over last year, but high when compared with the United States at 7.0 per cent, Japan at 2.8 per cent and West Germany at 8.0 per cent. Merchandise trade, historically the major stimulus to economic growth in Canada weakened considerably. Increasing imports and a decline in exports early in the year gave Canada its first monthly trade deficit in ten years in July. The overall trade surplus is estimated to be $11 billion, down from $17.5 billion in 1985 and the record $21 billion surplus in 1984. While total merchandise exports remained at last year's level of $120 billion, imports increased to $109 billion compared with $102 billion in 1985. As a result, the current account deficit climbed from $600 million in 1985 to $9 billion in 1986.

There were positive aspects to the economy in 1986. A steady decline in interest rates brought them to their lowest level in eight years. The federal deficit showed a decline of $5 billion, to $27 billion, after several years of increases. Investment spending, though down in the major resource sectors, increased by 17 per cent in manufacturing, and residential construction experienced a boom with housing starts exceeding 180,000, up from 165,000 in 1985. The inflation rate held steady at 4 per cent as lower oil prices were offset by higher sales and excise taxes.

The economies of Canada's main trading partners, the United States, Japan, Britain, West Germany and France, also slowed down in 1986. The sluggishness was partly the result of deliberate policy choices as many countries attemped to cut budget deficits and keep inflation under control, but the strongest impact came from the weakness of the U.S. economy. The United States had been a source of economic expansion for most countries throughout the 1980s with their open market trade policy. The resulting estimated merchandise trade deficit in the United States was $170 billion, up from a record $145 billion in 1985 and $45 billion in 1982. The estimated current account deficit reached almost $138 billion from a surplus position in 1981 of $7.6 billion. This, compared with a current account surplus of an estimated $105 billion in Japan and $35 billion in West Germany this year, generated concern and debate in the United States. Protectionist sentiments grew throughout the year bringing the possibility of higher tariffs and more inclusive import quotas. The United States maintained that their trade deficit was not the result of an inflated dollar (an argument used in the past) but of unfair trade tactics by trading

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partners. The value of the U.S. dollar declined 30 per cent during 1986 as the trade deficit worsened. By year-end, a turnaround was indicated with improvement being registered for three consecutive months. The U.S. economy grew by 2.6 per cent in 1986 as a result of the trade picture and in order to reverse the trend, they looked to other countries to open their markets to U.S. goods and services while consuming less foreign imports. The impact on export trade and growth in the Canadian economy has already been mentioned.

THE MINERAL INDUSTRY IN 1986

Those events which caused slower growth in the economy in 1986 had a direct impact on the performance of the mineral industry. Lower oil prices, decreasing business investment and slower export growth all contributed to a 24 per cent drop in the value of mineral production in 1986 compared with the previous year. The value of output for the industry including metallic minerals, industrial minerals and fuels totalled $33.9 billion compared with $44.7 billion in 1985, a $10.8 billion decrease. The fuel sector, including crude petroleum, natural gas, and coal accounted for almost all of that decrease. While the volume of petroleum output decreased by 0.7 per cent, the value of output dropped 47 per cent from $18.4 billion to $9.7 billion. Both volume and value of output declined for natural gas and coal as demand decreased.

Metallic minerals showed a better performance with value of output up 2.7 per cent from last year. The increase in value of output of gold, copper, lead, and molybdenum contributed to a total value of metal output of $8.9 billion compared with $8.7 billion in 1985. The value of industrial mineral output including nonmetals and structural materials remained unchanged from last year at $4.9 billion giving a total value of nonfuel mineral output for the year of $13.8 billion, a 2 per cent increase over the 1986 value of $13.6 billion.

The top ten commodities in terms of value of output in 1986 (1985 values appear in brackets) were: petroleum, $9.7 billion ($18.4 billion); natural gas, $6.7 billion ($8.0 billion); natural gas by-products, $1.8 billion ($2.8 billion); gold, $1.7 billion ($1.2 billion); coal, $1.7 billion ($1.8 billion); copper, $1.6 billion ($1.5 billion); zinc, $1.3 billion ($1.3 billion); iron ore, $1.3 billion ($1.5 billion); nickel, $1.1 billion ($1.2 billion); and uranium, $0.9 billion ($1.0 billion).

Alberta continued to be the largest contributer to mineral output with a value of $17.5 billion in 1986 but that total was down 35 per cent from $27 billion last year. Ontario came second with a value of $4.8 billion, up from $4.6 billion last year. Newfoundland, Manitoba, Saskatchewan and British Columbia saw decreases in their value of output of 12.1 per cent, 12.0 per cent, 32.2 per cent and 5.0 per cent respectively, while Nova Scotia and Quebec increased by 9.6 per cent and 1.4 per cent.

In terms of real output measured by Gross Domestic Product in 1981 dollars (a measure of physical volume of output), the nonfuel mining industry, is estimated to have increased from $6.1 billion in 1985 to $6.2 billion in 1986. The total output from primary metal industries including nonferrous smelters and refineries, and crude steel industries is estimated to have decreased from $3.9 billion in 1985 to $3.8 billion this year, while metallic and nonmetallic semi-fabricating and fabricating industries increased from $8.2 billion to $8.5 billlion. The value of output in 1981 dollars for the industry as a whole including mining and mineral manufacturing totalled $18.6 billion, up from $18.3 billion in 1985, and represented 5.2 per cent of the total output of the economy.

While value of output for nonfuel minerals increased in 1986 and metal prices showed some improvement, the industry continued to suffer from surplus capacity, sluggish demand and low profits. Cost cutting remained a priority throughout the year. Employment in metal mines, nonmetal mines and structural materials continued to drop from a peak level of 101 000 in 1981 to 78 000 in 1985 and an estimated 77 000 in 1986. Employment in smelting and refining, and crude steel industries remained about the same as last year at 77 000 down from the 1981 peak level of 95 000. Mineral manufacturing employment, on the other hand, increased to an estimated 224 000 from 217 000 last year. Employment in mining and mineral manufacturing totalled an estimated 379 000 in 1986, or 3.3 per cent of total employment in Canada.

Another area of cost cutting for the mining industry included capital and repair expenditures which totalled an estimated

$3.4 billion in 1986, down from $3.7 billion in 1985. The estimate of $3.4 billion was revised upwards from an earlier estimate of spending intentions total of $3.2 billion.

The availability of flow-through share financing was of considerable aid to the mining industry in 1986. Since its inception in 1983, the flow-through share program raised almost $750 million. The total amount raised in the first 11 months of 1986 was $346 million and is estimated to be $550 million for the year. Almost 85 per cent of that total was attributable to the search for gold across all areas of Canada. In Ontario, claims staked in the first six months of the year totalled 35 938, three times higher than for the same period in 1985 and rivalling the record year of 1983 when 70 314 claims were recorded.

Despite the sluggish worldwide demand for minerals in 1986, Canadian exports of crude and fabricated minerals, based on an estimate of nine-month data, totalled $16.2 billion, up from $15.5 billion in 1985. Crude minerals showed a slight decrease from a total of $5.2 billion last year to $5.0 billion this year but refined metals and fabricated mineral products increased from $10.4 billion to $11.2 billion. Of the total of all mineral exports, $10.6 billion or 65.4 per cent was destined for the United States compared with 61.5 per cent or $9.6 billion in 1985, $2.9 billion to the EEC, compared with $3.1 billion last year and $1.1 billion to Japan, the same as last year. Mineral exports represented 13.5 per cent of total Canadian merchandise exports in 1986, up from 12.9 per cent last year. Imports of crude and fabricated minerals totalled $8.3 billion. Net exports contributed almost $8.0 billion to the balance of trade surplus of $11 billion for 1986.

COMMODITY PRICES AND TRENDS

In terms of value of output in the nonfuel mineral industry, gold rose to number one in 1986. Volume of production reached 106 t, compared with 88 t last year and value of output climbed by more than $500 million to $1.7 billion as the Hemlo area came into full production. The price increased sharply in September reaching its highest level in three years and averaged $US 366.66 for the year compared with $317.27 in 1985. Given the conditions in South Africa and the Middle East combined with the possibility of increased protectionist policies in the United States, most analysts predict a positive outlook for gold in the near future. One dampening effect on price was the uncertainty concerning the level of U.S.S.R. exports. Price made platinum the star performer among all metals in 1986 rising from $US 350 in January to $600 in September. Some 80 per cent of total world non-Communist production originates in South Africa where a major labour dispute at Impala Platinum Holdings Ltd. contributed to that upward price trend. The fear of disruption of supply from South Africa, the increasing demand for platinum as an industrial metal as well as its increasing popularity as an investment were other reasons for its success among precious metals. Platinum in Canada is produced as a by-product in relatively small amounts mainly in Ontario.

Silver came a distant third among precious metals in 1986. Produced also as a by-product, volume rose slightly over the year but value decreased as the price fell. It dipped below $US 5 for the first time in five years as worldwide supply increased and averaged $7.91 for the year compared with $8.67 in 1985. With Mexico and Peru, the top two producers in the world continuing to increase output despite the price level, the outlook is uncertain for this metal.

The volume and value of output of copper increased 4 per cent and 7 per cent respectively and despite a decline in price from 68.48 US cents per pound in January to 60.97 cents in August, the average for the year was 66.59 cents, a slight improvement from the average 65.98 cents in 1985. It continued to fall short of the 1981 average of 101.42 cents and the more recent 1983 average of 77.83 cents per pound. Short term forecasts show little price improvement as present oversupply and the existence and possibility of development of new high-grade supply looms over the market. The price of lead also showed improvement in 1986 averaging 30.55 Cdn. cents per pound, up from 26.18 cents last year. Volume of output rose 13 per cent and value 32 per cent as production resumed at the Faro mine in the Yukon. Non-communist world market growth is predicted to be slow for the next few years at around 1 per cent. The Canadian value and volume of zinc output was almost unchanged from last year. Volume increased 1 per cent while value decreased 1 per cent and the price averaged 56.07 Cdn. cents per pound, slightly less than the 1985 level. Supply disruptions occurred during the year with strikes in Australia and Peru and mine closures in the

United States, keeping prices fairly firm but predictions for improvement are somewhat pessimistic. Galvanizing industries continued to be the major consumer of zinc and demand forecasts are tied to the automobile sector. Zinc consumption is not expected to change appreciably in the next few years, averaging an annual growth rate of 1.6 per cent to the end of this decade.

The Canadian nickel industry, characterized by serious oversupply, saw the price drop from $US 1.83 per pound in January to $1.65 by late in the year. The excess supply situation was exacerbated by the Soviet presence in the market. In 1986, the U.S.S.R. exported an estimated 40 to 50 per cent more nickel than usual to the Western markets. An increase in nickel demand was attributed to the increased use of primary nickel in stainless steel production in Western Europe and in the far east, excluding Japan. Inco Limited, with an estimated 30 per cent share of the market, was still by far the world's largest producer. Despite further cuts in operating costs, profits remained low for the year. The next year is not expected to show an appreciable improvement in the nickel market.

The output of molybdenum increased significantly in 1986 as some producers resumed operations after lengthy shutdowns. Volume of production fell from 11 557 t in 1984 to 7 852 t in 1985, then recovered to 12 914 t this year. Iron ore continued to suffer from offshore competition and a lagging North American steel industry. Volume and value of production fell in 1986 as closures continued. Six producers remain, down from seventeen in 1979, and forecasts show little improvement for the rest of the 1980s. The Canadian uranium industry, having the world's richest deposits, lowest production costs and highest exports, braced itself for protectionist initiatives on the part of the U.S. producers. Exports to the United States represented almost a third of the total value of Canadian production in 1986. The potash industry came under the same pressure from U.S. producers. Sixty per cent of Canadian production of potash is destined for the United States and the worldwide industry was plagued with 4 to 5 million t of excess supply. The price fell to $55 per t in 1986 from a high of $100 in 1979. A turnaround is not predicted until the mid-1990s.

Asbestos continued to be pressured by health concerns and shrinking demand. Volume of production fell for the sixth consecutive year. Other nonmetals remained stable with moderate growth throughout the year. Structural materials benefited from the residential construction boom and increased from $2.1 billion in 1985 to $2.2 billion in 1986.

OUTLOOK

Stronger economic growth in Canada is predicted for 1987. This prediction is based on the assumption that growth in the United States will also improve. The depreciation of the U.S. dollar during the last two years has made American goods more competitive abroad and the United States will recapture some market share. The expected turnaround in the U.S. trade account will strengthen its economy and Canadian export growth should improve as a result.

Overall business investment in Canada will increase in 1987 by 3 to 4 per cent. Resource prices, particularly oil prices, are expected to stabilize. Since OPEC signed an agreement on December 21, 1986, the price of crude oil rose above $US 17 per barrel for the first time since May. The increase in oil prices should bring about some recovery in investment in the Canadian energy sector. Non-resource investment having maintained a steady growth in 1986 will continue to increase in 1987. Analysts assume that fiscal restraint will continue in an attempt to further reduce the federal deficit and the pressure on interest rates. The delayed income gains to be realized by consumers due to reduced oil prices should be felt early in the year.

The resulting increase on overall economic activity will contribute to a growth rate in real output of 3.5 per cent during 1987. This growth rate is also predicted for the Canadian mineral industry in 1987. Action plans for mining companies throughout the difficult 1980s included rationalizing or reducing the size of operation and investing in new technology to improve their productivity and to strengthen their competitive position. The industry is presently lean enough to profit by any improvements in metal prices.

One area of concern to the mineral industry next year will be the impact of overall trade negotiations with the United States. Free trade in terms of absence of duties and tariffs has long been in place for most crude mineral products from Canada. The Canadian potash and uranium industries will be the subject of trade discussions with the United States during 1987.

The industry will continue to deal with the advancing inroads made by new substitutes such as plastics, ceramics, composites, glass and optical fibres. Predictions of strong competition from these products in the early 1990s have led to increased concern about the level of investment in research and development by mining companies. New mineral-based materials and products will be the guarantee for growth in the long term in the industry.

The performance of the mineral industry in 1986 was influenced by considerable price declines for energy commodities while non-energy commodities either stabilized or experienced price improvements. The non-energy component of the industry appears to have stabilized in terms of capacity and ability to compete on world markets. This sector of the industry is becoming more anticipatory rather than reactionary to world demand for its products.

CANADA, PRODUCTION OF LEADING MINERALS, 1985 AND 1986

	1985	1986	Per cent change 1986/1985	1985	1986	Per cent change 1986/1985
	(000 tonnes except where noted)			($ millions)		
Metals						
Copper	738.6	768.2	+4.0	1,466.9	1,568.0	+6.9
Gold (kg)	87 562.0	104 655.0	+19.5	1,219.7	1,715.4	+40.6
Iron ore	39 502.0	36 096.0	-8.6	1,462.3	1,254.8	-14.2
Lead	268.3	303.5	+13.1	154.8	204.4	+32.0
Molyodenum (t)	7 852.0	12 914.0	+64.5	74.4	113.9	+53.1
Nickel	170.0	180.6	+6.2	1,217.4	1,075.5	-11.7
Silver (t)	1 197.0	1 219.0	+1.8	333.8	310.1	-7.1
Uranium (tU)	10 441.0	10 977.0	+5.1	1,002.1	923.8	-7.8
Zinc	1 049.3	1 055.1	+0.6	1,315.8	1,304.1	-0.9
Nonmetals						
Asbestos	750.0	640.0	-14.7	298.6	300.6	+0.7
Gypsum	8 447.0	8 542.0	+1.1	75.1	80.6	+7.3
Potash (K_2O)	6 661.0	6 969.0	+4.6	629.5	579.0	-8.0
Salt	10 085.0	11 088.0	+9.9	215.4	241.6	+12.2
Sulphur, elemental	8 102.0	6 868.0	-15.2	1,026.2	927.1	-9.7
Cement	10 192.0	10 058.0	-1.3	788.4	790.8	+0.3
Clay products	..	..	..	138.2	180.4	+30.5
Lime	2 212.0	2 364.0	+6.9	182.4	206.4	+13.2
Fuels						
Coal	60 436.0	57 800.0	-4.4	1,845.1	1,716.0	-7.0
Natural gas (million m^3)	84 344.0	76 365.0	-9.5	8,047.7	6,743.8	-16.2
Petroleum (000 m^3)	85 564.0	84 964.0	-0.7	18,417.8	9,719.2	-47.2

.. Not applicable.
Note: Figures have been rounded.

CANADA, EXPORTS OF MINERALS, BY STAGE OF PROCESSING[1]

	Year			1st 9 months		% changes 1st 9 months 1986 / 1st 9 months 1985
	1975	1980	1985	1985	1986	
	($ millions)					
Crude						
Ferrous	686.3	1,241.3	1,172.9	938.0	778.7	-17.0
Nonferrous	811.3	1,598.7	910.7	683.8	748.4	+9.4
Industrial	798.6	2,369.5	3,074.0	2,378.3	2,188.3	-8.0
Fuels	4,688.4	8,055.5	12,079.8	8,989.1	6,360.2	-29.2
Total	6,984.6	13,265.0	17,732.1	12,989.2	10,075.6	-22.4
Scrap						
Ferrous	35.2	101.7	110.4	79.8	70.1	-12.2
Nonferrous	102.4	430.5	384.3	275.2	312.3	+13.5
Total	137.6	532.2	494.7	355.0	382.4	+7.7
Smelted and refined						
Ferrous	111.9	284.8	242.1	169.7	199.0	+17.3
Nonferrous	2,187.6	6,372.2	6,246.3	4,751.4	5,302.0	+11.6
Fuels	706.3	2,596.0	3,445.4	2,454.0	1,908.5	-22.5
Total	3,005.8	9,253.0	9,933.8	7,375.1	7,409.5	+0.5
Semi-manufactured						
Ferrous	651.8	1,789.7	2,158.1	1,671.7	1,552.7	-7.1
Nonferrous	213.4	622.1	800.7	611.5	634.9	+3.8
Industrial	322.3	662.7	915.8	686.4	750.6	+9.4
Fuels	13.1	353.6	488.7	386.5	154.0	-60.2
Total	1,200.6	3,428.1	4,363.3	3,356.1	3,092.2	-7.9
Total mineral exports (including scrap)	11,328.6	26,478.3	32,523.9	24,075.4	20,959.7	-12.9
Total domestic exports, all products	32,586.9	74,446.0	115,911.6	85,542.7	85,885.1	+0.4
Crude minerals as % of exports, all products	21.4	17.8	15.3	15.2	11.7	
Total minerals as % of exports, all products	34.8	35.6	28.1	28.1	24.4	

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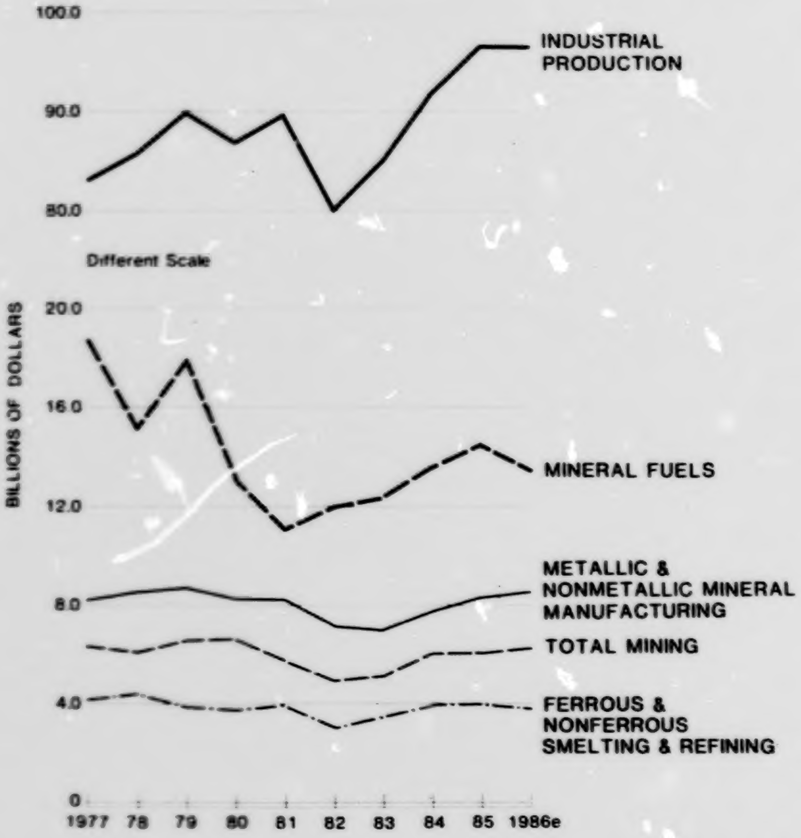
[1] The trade data was compiled on the basis of a mineral industry definition developed by the Mineral Policy Sector of EMR in 1977.

FIGURE 1

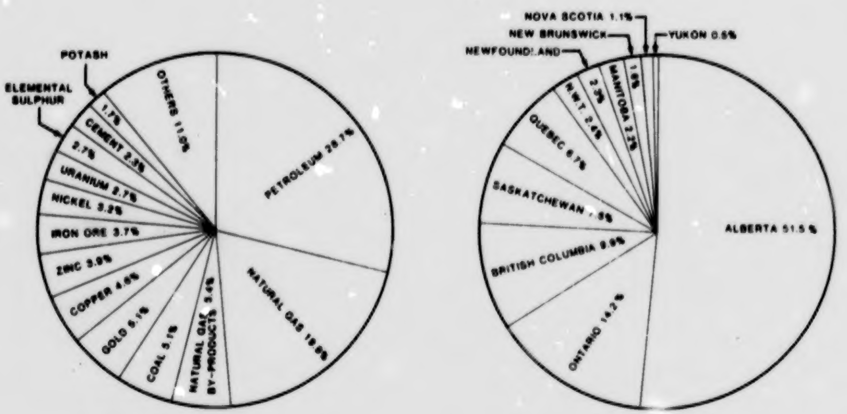
GROSS DOMESTIC PRODUCT
In 1981 Dollars



SOURCE: STATISTICS CANADA

FIGURE 2

CANADA, MINERAL PRODUCTION, 1986



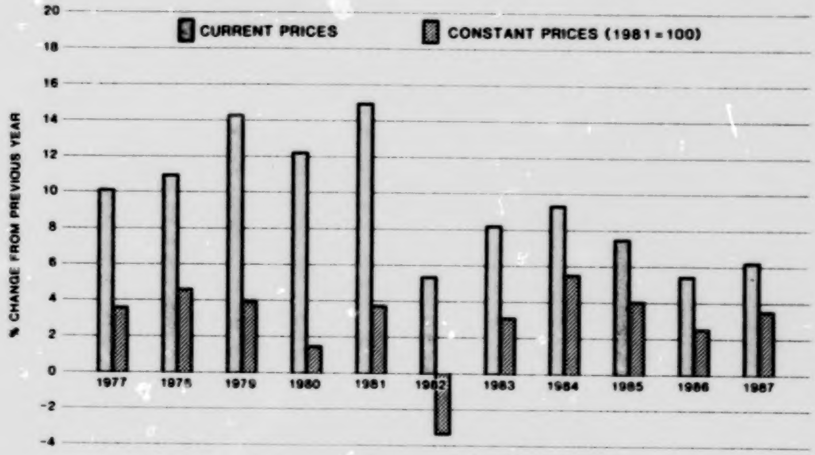
% OF TOTAL BY COMMODITY

% OF TOTAL BY PROVINCE

FIGURE 3

TRENDS IN CANADIAN ECONOMIC ACTIVITY

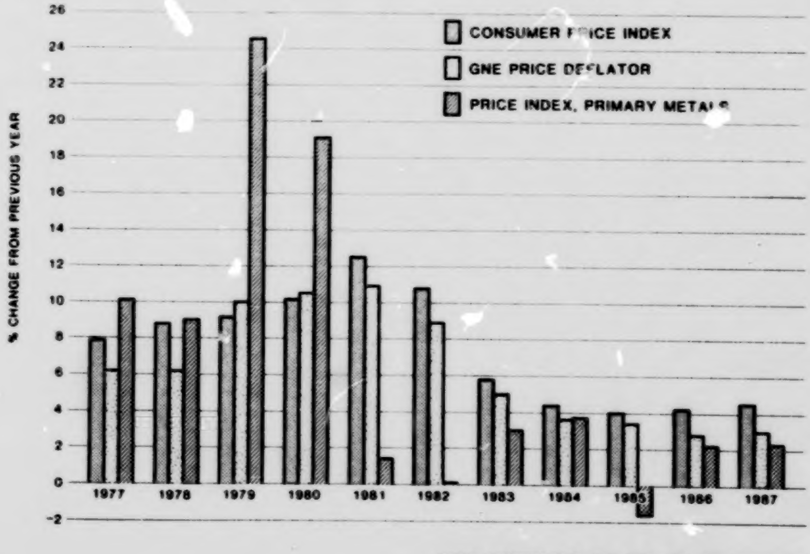
(%CHANGE IN GROSS DOMESTIC PRODUCT)



NOTE: FIGURES FOR 1986 AND 1987 ARE ESTIMATED

FIGURE 4

GENERAL CANADIAN PRICE TRENDS



NOTE: FIGURES FOR 1986 AND 1987 ARE ESTIMATED

International Review

W.H. JACKSON

Canada's economy is heavily dependent on the trade in products of the resource industries - minerals, energy, agriculture, forestry and fisheries. The mineral industry continues to make a significant contribution to Canadian balance of payments even in the highly competitive markets that exist today.

The major events of 1986 that affected the mineral industry were the re-alignment of currencies and lower interest rates. These changes will affect the pattern of mineral trade and could improve the prospects for growth in the world economy. There are other international issues worth watching in 1987. For example, the international debt problem is not over but seems manageable.

CANADA'S NONFUEL MINERAL TRADE

Preliminary data for 1986 indicate that mineral exports increased by 4.4 per cent to $Cdn 16.2 billion while imports increased 7.5 per cent to $Cdn 8.3 billion. This performance is impressive and, if there is any improvement in the world economy, the trade results for minerals could improve further in 1987.

Canada's major trading partners for both imports and exports are the United States, the European Economic Community and Japan. Tables 1 and 2 show the overall trade performance of the mineral industry.

TRADE ISSUES

The past year has seen a resurgence of protectionist sentiment in various countries with the result that there have been attempts to affect long established trade patterns while addressing questions of injurious trade flows.

The Canada-United States relationship was a stark example of how the recessionary pressures of the early-1980s have led to a deviation from the growing historical pattern of mutual interdependence.

The short-term trend is for particular U.S. industries to seek competitive advantage by promoting protectionist actions. For example, there was an attempt to include cement in the "Buy America", provisions of the U.S. Federal Surface Transportation Assistance Act. Voluntary restraint agreements on steel are in place with a number of countries, not including Canada. There are, however, quotas on Canadian stainless and specialty steels. Potash interests are trying to make a case for their industry. It is noteworthy that the Superfund Tax Bill in the United States imposes new taxes to finance a clean up of toxic wastes but some parts of the United States industry are still claiming that Canada is subsidizing industry by its policy of cleaning up the environment. Hopefully, the validity of many of the arguments will continue to be reviewed with patience and common sense.

Negotiations on a closer trading relationship with the United States are under way and may conclude in 1987. In this respect, we may have something to learn from New Zealand and Australia. These countries have developed a Closer Economic Relations Agreement which should cover all products by the time it is revised in 1988.

GENERAL AGREEMENT ON TARIFFS AND TRADE

For the longer term, the most significant event for the mineral industry will be the outcome of a new round of Multilateral Trade Negotiations to be called the "Uruguay Round". These negotiations were agreed to in September 1986 and will be concluded within four years. The purpose is to reverse protectionism, remove distortions to trade, further the objectives of the General Agreement on Tariffs and Trade, and develop a more open and durable multilateral trading system. The linkage between trade, money, finance, and development is recognized.

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For natural resource-based products, the negotiations aim to achieve the fullest liberalization of trade including processed and semi-processed forms. Attempts will be made to reduce or eliminate tariff and non-tariff measures. A successful outcome will give the mining industry much of what it needs in terms of market access.

WORLD BANK

New initiatives by the World Bank may have an impact on overseas investments. An affiliate, the International Finance Corporation recently announced a new service, Guaranteed Recovery of Investment Principal (GRIP). This action together with the Multilateral Investment Guarantee (MIGA) will enhance the attractiveness of investment in developing countries to which it applies. The two facilities will reduce risk for investors.

METALS OVERVIEW

The international picture is particularly important as it sets the context in which decisions are made. It follows that the picture must be accurately drawn. The mineral industry produces a wide range of products that enter world trade. Gold had a particularly good year. Asbestos has the problem of controlled use and fertilizer minerals were affected by problems in agriculture. However, consumption of many commodities is slowly increasing, although at a much lower rate than in the past. While chronic overcapacity exists, visible inventories are declining for many commodities which suggests that market forces are slowly bringing supply and demand into balance. It is worth noting that the IMF index of world metal prices (measured in U.S. dollars) was stable in 1986 with the price level about 65 per cent of the price level prevailing in 1980.

On this basis there may be room for modest increases in internationally determined prices in 1987. However, even for depressed industries such as steel, increased efficiencies are evident in turning out more useable product for many applications at lower costs. Structural adjustment in the mineral industry is an on-going process and much of it is positive as the application of new technology aids the rejuvenation process while at the same time often lowers operating costs.

COMMODITY STUDY GROUPS

One way to establish an accurate picture of markets is through participation in international commodity study groups such as those existing for lead-zinc and tungsten. The formation of a new nickel study group is receiving considerable support. This type of co-operation between producers and consumers does not require any actions to control price or supply as is the case for commodity agreements. Preliminary discussions also took place for copper and tin in 1986 and more substantive discussions are expected in 1987. The commodity reviews in this series contain more information on these developments.

In responding to the competition for future markets, Canadian industry and governments along with labour, have mutual interests in ensuring the competitiveness of Canadian industry since it is export dependent and a price taker in international markets, not a price setter. If Canadian industry is to maintain its market share, it is obvious that the changing needs of customers must be well known with products delivered to specification and at a competitive price. The competitive pressures on the Canadian mining industry are not likely to lessen significantly in 1987.

TABLE 1. CANADA'S NONFUEL MINERALS EXPORTS 1985 AND 1986, BY MAJOR MARKET AND STAGE OF PROCESSING[1]

	1985				1986[2]			
	United States	EEC[3]	Japan	Total	United States	EEC[3]	Japan	Total
				($ million)				
Crude								
Ferrous	453.1	805.2	67.2	1,172.9	465.7	663.6	32.0	1,038.3
Nonferrous	119.5	368.1	460.5	910.7	96.8	432.5	537.7	997.9
Industrial	973.7	444.7	164.5	3,074.0	857.2	495.2	114.1	2,917.7
Total	1,546.3	1,618.0	692.2	5,157.6	1,419.7	1,591.3	683.8	4,953.9
Scrap								
Ferrous	57.3	33.8	6.6	110.4	58.8	21.0	6.3	93.5
Nonferrous	241.7	158.3	18.5	384.3	281.7	122.7	27.6	416.4
Total	299.0	192.1	25.1	494.7	340.5	143.7	33.9	509.9
Smelted and refined								
Ferrous	140.8	72.8	21.0	242.1	164.8	69.1	11.5	265.3
Nonferrous	4,417.5	1,152.5	385.7	6,246.3	5,519.7	1,040.1	316.4	7,069.3
Total	4,558.3	1,225.3	406.7	6,488.4	5,684.5	1,109.2	327.9	7,334.6
Semi-manufactured								
Ferrous	2,011.5	20.3	2.2	2,158.1	1,933.5	30.5	1.8	2,070.3
Nonferrous	592.7	179.5	27.8	800.7	639.3	187.2	39.1	846.5
Industrial	850.6	29.3	3.3	915.8	926.4	28.1	4.8	1,000.8
Total	3,454.8	229.1	33.3	3,874.6	3,499.2	245.8	45.7	3,917.6
Grand total (excluding scrap)	9,559.4	3,072.4	1,132.2	15,520.6	10,603.4	2,946.3	1,057.4	16,206.1
Percentage of grand total	61.6	19.8	7.3		65.4	18.2	6.5	

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[1] The trade data compiled on the basis of a mineral industry definition developed by the Mineral Policy Sector of EMR in 1977. [2] 1986 estimates based on nine month data. [3] EEC: Belgium, Denmark, France, West Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, United Kingdom and Greece.

TABLE 2. CANADA'S NONFUEL MINERALS IMPORTS 1985 AND 1986, BY MAJOR MARKET AND STAGE OF PROCESSING[1]

	1985				1986[2]			
	United States	EEC[3]	Japan	Total	United States	EEC[3]	Japan	Total
				($ million)				
Crude								
Ferrous	327.6	...	-	349.1	235.5	...	0.1	255.5
Nonferrous	361.4	11.2	-	578.0	736.8	18.1	-	938.4
Industrial	295.2	22.2	0.3	344.2	294.4	22.5	0.1	349.7
Total	984.2	33.4	0.3	1,271.3	1,266.7	40.7	0.2	1,543.6
Scrap								
Ferrous	77.9	...	-	78.1	67.3	...	-	67.5
Nonferrous	199.9	20.2	...	329.7	218.4	29.5	...	400.5
Industrial	0.5	-	-	0.5	0.8	-	-	0.8
Total	278.3	20.2	...	408.3	286.5	29.5	...	468.8
Smelted and refined								
Ferrous	79.1	44.4	0.1	162.1	73.9	78.9	8.4	201.2
Nonferrous	1,652.7	159.1	69.8	2,245.7	2,033.6	120.6	69.7	2,529.6
Total	1,731.8	203.4	69.9	2,407.8	2,107.5	199.5	78.1	2,730.8
Semi-manufactured								
Ferrous	897.8	654.6	245.0	1,885.8	743.6	581.9	225.3	1,705.0
Nonferrous	683.5	144.3	20.7	863.8	785.2	135.9	21.9	963.2
Industrial	874.7	306.7	49.0	1,290.3	878.1	344.1	60.9	1,360.0
Total	2,456.0	1,105.6	314.7	4,039.9	2,406.9	1,061.9	308.1	4,028.2
Grand total (excluding scrap)	5,172.0	1,342.4	384.9	7,719.0	5,781.1	1,302.1	386.4	8,302.6
Percentage of grand total	67.0	17.4	5.0		69.6	15.7	4.7	

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[1] The trade data compiled on the basis of a mineral industry definition developed by the Mineral Policy Sector of EMR in 1977. [2] 1986 estimates based on nine month data. [3] EEC: Belgium, Denmark, France, West Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, United Kingdom and Greece.
... Amount too small to be expressed; - Nil.

Regional Review

VALERIE FELL

The value of Canadian metallic mineral production in 1986 was $8.9 billion, an increase of $262 million, or 3 per cent, above the previous year. Non-metals declined 2.5 per cent and structural materials increased by 3.5 per cent. The total value of mineral production, which includes petroleum and natural gas, decreased by $10.8 billion or 24 per cent. Output of the energy commodities decreased by over $11 billion, or more than 35 per cent. Physical output of crude petroleum remained close to 1985 levels, but the value decreased by 47 per cent or $8.6 billion.

Mineral Development Agreements (MDAs) between Canada and Newfoundland, Nova Scotia, New Brunswick, Manitoba and Saskatchewan were in the third year of their planned five-year terms and, for the most part, were progressing well. MDAs with Ontario, Quebec and British Columbia, which were signed a year later, entered their second year in April 1986 and also were making progress. A small MDA with Prince Edward Island got under way in April 1986. These MDAs are subsidiary to federal-provincial Economic and Regional Development Agreements (ERDAs), which provide for consultation between the two levels of government on all matters relating to economic development in the regions and the identification of initiatives that can be pursued under subsidiary agreements.

In the north, the Canada-Yukon Mineral Resources Agreement entered its second year. It is similar to the MDAs and is under the umbrella of the Canada-Yukon Economic Development Agreement. Indian Affairs and Northern Development is the lead federal department with participation by Energy, Mines and Resources. During the year, negotiations were under way for an agreement with the Northwest Territories.

Energy, Mines and Resources is the responsible federal department in the federal-provincial MDAs. All the MDAs have major geoscience programs for generating the data that industry needs for mineral exploration. Some also have programs dedicated to improvements in mining and processing technology, the identification of opportunities for mineral development, the direct stimulation of mineral development, and public information. The total federal commitment, on the basis of the five-year terms of the MDAs, is $134.7 million; provincial commitments total $108.9 million.

NEWFOUNDLAND

From 1985 to 1986, the value of mineral production decreased by 12 per cent to $764 million. Output of the three most important commodities fell in value in 1986; production of iron ore was $702 million, down from $774 million; zinc output fell to $8 million from $41 million; and asbestos shipments were $18 million compared with $18.2 million.

The exploration industry was very active in 1986; expenditures are estimated to be $15 million, up from $12 million the previous year. The number of claims in good standing increased to an all time high of over 32 500 during the year.

Behind this exploration activity, the driving force was again gold. Hope Brook Gold Inc. announced that its Chetwynd gold deposit near the southwest coast will start open-pit mining with gold extraction by heap leaching in mid-1987. A 3 000 tpd mill is scheduled to start up in early 1988. Westfield Minerals Limited, The Coniagas Mines, Limited and Anglo Dominion Gold Exploration Limited, announced late in 1986 the discovery of stratabound gold in the Bay d'Espoir region, about 160 km east of the Chetwynd deposit. Both deposits lie on the Hermitage Flexure, a structure delineated under a previous Canada-Newfoundland Mineral Development Agreement and not previously known to be a significant host to gold mineralization. Mascot Gold Mines Limited is drilling on the Cape Ray deposit northeast of Port aux Basques.

Other areas with new or significantly increased exploration activity are western White Bay, the Baie Verte Peninsula, Springdale, Buchans-Millertown, Bay St. George and northern Labrador.

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There was a sharp increase in exploration for platinum in Newfoundland and Labrador in 1986. International Platinum Corporation explored in the Kiglapait Mountains, north of Nain, Labrador and has staked other claims in Labrador. Several companies have been conducting reconnaissance programs on ultramafic complexes in insular Newfoundland.

Newfoundland Zinc Mines Limited's Daniel's Harbour mine on the west coast closed temporarily in April 1986 because of low zinc prices.

Iron Ore Company of Canada (IOC) began mining high-quality dolomite at Lelia Lake, Labrador for use in self-fluxing pellets at its Labrador City plant.

At Nut Cove, Trinity Bay, Island Tile & Slate Limited is developing a slate quarry. Production is committed to U.S. markets at present and prospects look excellent for increased capacity and production in future years.

At Long Harbour, ERCO Industries Limited uses silica as flux to extract phosphorus from phosphate rock imported by ship from Florida. The formerly stockpiled slag is now being crushed and loaded for the return trip. The material is to be used as aggregate for road construction.

First production of fluorspar from Minworth Ltd.'s mine at St. Lawrence is expected in early 1987. This is a rebirth of mining operations on the southern tip of the Burin peninsula which were active from 1933 to 1978.

Apart from a 2½ month summer shutdown at Wabush Mines caused by reduced demand from the U.S. steel industry, iron ore production continued at about 19.4 million tpy. It is expected that output in 1987 will be about the same.

Highlights of work carried out under the 1984-89, $22 million Canada-Newfoundland Mineral Development Agreement geoscience program included continued geological mapping in Labrador and northern Newfoundland; the completion of the regional geochemical survey of Labrador; and metallogenic studies at a number of base metal deposits.

Under the mining and mineral technology program a high-grade silica deposit in Labrador was examined and work continued on iron ore recovery techniques and on improvements in pellet production technology. Several studies on industrial mineral markets were initiated.

NOVA SCOTIA

In 1986, the value of mineral production in Nova Scotia increased by 9.6 per cent, from 1985, to $356 million, of which $176 million was for coal and $50 million for gypsum.

About $25 million were spent on exploration in 1986, primarily for gold. This is up considerably from 1985 when an estimated $8 million was spent. Some of this increased exploration expenditure can be attributed to the Canada-Nova Scotia Mineral Development Agreement, which was progressing well in the third year of a five-year term in 1986. Many of the projects under the agreement are now providing results that are influencing exploration decision-making in the province.

Seabright Resources Inc. was the largest investor with a total expenditure of nearly $16 million on gold exploration and predevelopment work on its Beaver Dam property in Halifax County and Forest Hill property in Guysborough County. Rehabilitation of the former lead-zinc mill at Gays River also accounted for a significant portion of these funds.

Scominex is carrying out a $1 million underground exploration and bulk sampling program on the Cochrane Hill gold property in Guysborough County.

Georgia-Pacific Corporation is opening a new gypsum quarry at Sugar Camp, Inverness County. This quarry will eventually replace the one at River Denys as reserves there become depleted.

Mosher Limestone Company Limited will invest $1 million in a new quarry at Kelly Cove, Victoria County, to produce limestone for agricultural purposes.

Sifto Salt, a division of the Domtar Chemicals Group, has completed a $9 million investment in its plant at Nappan to provide a totally new energy-efficient process for making evaporated salt.

At year-end, the future of the East Kemptville tin mine was in doubt. After resolving a problem with suspended solids in effluent waters during the year, Rio Algom Limited turned the property over to its creditors, a banking consortium led by Bank of America/Canada. The mine was project-financed on the basis of tin reserves on the property. Rio Algom has indicated it would be prepared to continue to operate the mine on behalf of the banks but would not contribute cash to the operation to meet the bank loan repayments.

NEW BRUNSWICK

In 1986, the value of mineral production in New Brunswick increased by 3.4 per cent to $526 million, of which $205 million was for zinc, $51 million for lead, $51 million for silver, and $26 million for coal.

The mining industry plays a vital role in New Brunswick's growth and development, employing 5 000 people directly. The non-metallic sector continues to grow mainly because of potash. Although the number of claims recorded during 1986 was down compared to 1985, activity was still strong as nearly 2 600 claims were staked during the year. Exploration expenditures totalled approximately $3 million, up slightly from 1985. Exploration for gold has increased during 1986 and will continue to be active in 1987.

Brunswick Mining and Smelting Corporation Limited registered its first operating loss in 1985 and losses continued into 1986, because of continuing low demand for base metals resulting in low zinc, lead and silver prices. To cut costs, Brunswick has reduced its workforce and plans to make better use of employees and technology.

Heath Steele Mines Limited and the University of New Brunswick commenced a three-year study to obtain detailed structure and stratigraphic data on the deposit. Funding for this work is being provided by the Canada-New Brunswick Mineral Development Agreement. It is anticipated that this work will provide targets for drilling that could increase the ore reserves and thus improve the mine's economic status. The mine ceased underground operations in 1982 and is in a state of care and maintenance.

Gordex Minerals Limited produced the first gold bar from the open-pit Cape Spencer property in June 1986. The Gordex mine is the first in Canada to use the heap leach process and the first primary gold producer in the province. Exploration near the mine site will be ongoing during 1987 to increase known reserves. Nearby, Mispec Resources Inc.'s gold property has undergone exploration on the 11 mineralized zones lying on favourable geological extensions of the Gordex property.

Encouraging results from diamond drilling by Lacana Mining Corporation at Elmtree, near Bathurst, included gold values over significant widths and depth. In the same area, Northumberland Mines Limited has announced plans to produce gold and silver from the Murray Book deposit in 1988.

Potash Company of America, Inc. (PCA) and Denison-Potacan Potash Company operated the potash mines near Sussex during the year. Durham Resources Inc. plans underground exploration and development work for next year at its antimony mine at Lake George.

Fourteen peat bogs were in production and several operations are either being explored or are in the development stage. The Peat Research and Development Centre at Shippegan was officially opened in May, in cooperation with the University of Moncton.

The five-year, $22.3 million Canada-New Brunswick Mineral Development Agreement (MDA) entered the third year. Numerous geoscience, mining and minerals technology and economic development projects were underway and aimed at stimulating the mining industry of the province. Projects included metallogenic studies, mapping, and geophysical surveys; evaluation of mineral aggregates for alkali reactivity, manganese sampling, treatment technology, potash mineralogy studies and backfill tests; and commodity market studies.

In November, a new drill core storage facility was officially opened at Sussex. The $250,000 MDA-funded project is designed with storage space for 60 960 m of drill core.

QUEBEC

In 1986, the value of mineral production in Quebec decreased slightly (2 per cent) to $2.18 billion. With the exception of gold and construction materials, most commodities experienced a decline in value and in quantity.

In spite of that, 1986 was a good year for the mineral sector as exploration expenditures and investments in mining development increased significantly compared to the previous year. Major discoveries of gold and base metals near Matagami and in the Casa Berardi area, combined with the attractive flow-through share tax provision, including the extension of January-February eligibility, permitted exploration expenditures in 1986 to exceed the record level established in 1985. Such expenditures were mainly directed towards the search for precious metals or polymetallic deposits. The increase in mining development expenditures are partly the result of spending generated by a former Quebec government program that was aimed at accelerating investment in the mineral sector. Under this program, the Quebec government invested $120 million in 18 projects to generate more than $700 million in new investment.

Among the minerals produced in Quebec, gold ranked first with an estimated value of $477 million, followed by iron ore at $400 million, asbestos at $200 million, and cement at $192 million. Higher prices are responsible for an increase of 17 per cent in the value of gold produced; the volume of production remained unchanged from the previous year.

A poor market for steel is responsible for the decrease of 11 per cent in the value of iron ore produced. The value of asbestos continued to decline and dropped by 18 per cent in 1986. Asbestos fiber production is estimated at 500 000 t compared with 1.2 million t in 1980.

The controlled use approach for asbestos supported by Canada was adopted by the International Labour Organization (ILO) in June of 1986. Canada is encouraging the ratification of the ILO decision by all the provinces.

In December 1986, Quebec Minister for Mines and Native Affairs, Raymond Savoie, introduced an amendment to the mining legislation at the National Assembly. The new legislation aims mainly at giving better access to mineral resources by providing a prospector's permit, valid for a five-year period, and by granting a claim for a two-year period.

The Canada-Quebec Mineral Development Agreement, by which the two levels of government agreed to spend a total of $100 million over a five-year period ending in 1991, was amended in 1986. The Agreement originally consisted of the five following programs: Geoscientific Activities; Asbestos R&D; Mineral Infrastructure Assistance Program; Opening Up of the Iron Ore Industry and Public Information. The amendment added three new programs: a program on technical and economic studies and experimental activities, a program to implement an automated production and distribution system for geoscientific documentation and a program on the defence and promotion of asbestos.

ONTARIO

In 1986, the value of Ontario mineral production increased by 3.6 per cent over 1985 and is now worth $4.8 billion. Metals and nonmetallic minerals accounted for 79 per cent of this value and structural materials for 19 per cent. Of the total amount, $815 million was for nickel, $590 million for copper, $476 million for uranium, $375 million for zinc and $765 million for gold.

The exploration industry was very active in 1986, with gold being the main target. Although activity was centered around established mining camps, recent developments have encouraged work in other locations. The discovery of a new gold deposit by St. Joe Canada Inc. in the Pickle Lake area resulted in much exploration and staking activity. The intersection of a wide zone of gold mineralization in the Beardmore-Geraldton area has companies re-examining this former gold camp. Encouraging results by several companies are evident in the Harker-Holloway and Timmins areas.

At Timmins, the Dome mine, in its 76th year of production, plans a $14 million improvement and expansion program to change its gold extraction process from cyanidation to carbon-in-pulp. Canamax Resources Inc. announced that it will begin mining gold from its Bell Creek Property in Hoyle Township by the first quarter of 1987 and plans to construct a 350 tpd mill which will be operational in the fall of 1987. At year-end, ERG Resources Inc. announced that the reprocessing of 140 million t of gold-bearing tailings will begin in 1989.

In the Kirkland Lake area, the Macassa mine of Lac Minerals Ltd. has recently completed the deepest single-lift, timbered, vertical shaft (2 202 m) in the western hemisphere, at a capital cost of $37 million. Eastmaque Gold Mines Ltd. plans to recover gold from more than 6 million t of tailings in the area. The McBean mine closed operations in September 1986. Golden Shield Resources Ltd. plans production from the Mirado gold property in January 1987, using the McBean mill. The Holt-McDermott property of American Barrick Resources Corporation in Holloway Township will begin production in the second quarter of 1988.

The Mishibishu area south of Wawa also has seen activity during 1986. The MacMillan Energy Corp./Granges Exploration Ltd. joint venture did extensive fill-in diamond drilling, which has extended the known gold zone to the east and north. The Flanagan McAdam Resources Inc. property has recently increased reserve calculations and an underground ramp is advancing at a good rate.

The three Hemlo mines of Lac Minerals Ltd., Noranda Inc. and Teck Corporation all began production last year, resulting in Ontario being the foremost gold producing province. These mines are forecast to account for 25 per cent of Canada's production of gold by 1990.

The Detour Lake mine, 140 km northeast of Cochrane, is undergoing a 17-month underground evaluation program. The forecast reopening is December 1987.

In the northwestern part of the province, the Griffith iron ore mine ceased operations in March 1986. The two relatively high-grade gold mines at Red Lake, the Arthur W. White and Campbell Red Lake, continue producing and exploration activities in this camp are ongoing. The Favourable Lake gold-silver property will see an exploration and development program begin in April 1987 by joint venture partners Zahavy Mines Limited and Getty Mines, Limited. The property has been in a care and maintenance status since 1983. Work progresses at the Dona Lake and Opapimiskan Lake gold properties.

The uranium operations of Rio Algom Limited and Dickenson Mines Limited at Elliot Lake continue to supply 45 per cent of Canada's uranium output. In September 1986, a $10 million joint-venture plant was commissioned to recover yttrium oxide from Denison's uranium operations in a joint venture with Molycorp, Inc., Shin-Etsu Chemical Co. and Mitsui & Co., Ltd. of Japan.

At Wawa, The Algoma Steel Corporation, Limited's MacLeod Mine has been experiencing economic difficulties. The company has been exploring, with Algoma Central Railway, means of reducing transportation costs. In the same area, Citadel Gold Mines Inc. plans to reactivate its mining operation by mid-1987 and to refurbish the 750 tpd mill.

Corporation Falconbridge Copper reactivated the high-grade Winston Lake zinc property, the 22 km road to highway 17 has been upgraded, and full production will begin early in 1988.

The significant rise in platinum prices last year encouraged staking and exploration programs in the Lac des Îles, Marathon and Big Trout Lake areas. The Madeleine Mines Ltd. property at Lac des Îles is expected to go into production at 3 000 to 3 500 tpd, late in 1987.

The reorganization of the Ontario Ministry of Northern Development and Mines has given added impetus to Ontario's mining industry. Ontario also added $4 million to the $8 million budget of the Ontario Mineral Exploration Program (OMEP) for the 1986-87 fiscal year. OMEP pays 25 per cent of the exploration costs for eligible Ontario mining projects.

Under the first full field season of the five-year, $30 million Canada-Ontario Mineral Development Agreement (COMDA), geoscience parties were active in all the areas designated for geoscientific work. About $4 million will have been spent by March 31, 1987. In addition, contracts for more than $1 million have been signed for research into deep mining technology in the Sudbury area. A $2 million access road has been completed, linking highways 66 and 101, north of Kirkland Lake.

MANITOBA

In 1986, the value of Manitoba's mineral production decreased by 12 per cent, from 1985, to $758 million, of which $259 million was for nickel, $94 million for crude petroleum, $141 million for copper and $71 million for zinc.

Mining provides the principal economic base for the northern communities of Flin Flon, Lynn Lake, Snow Lake, Leaf Rapids and Thompson. Low metal prices and declining ore reserves and grades since 1982 have caused intermittent mine closures and the layoff of hundreds of employees. This has even threatened the existence of several of the communities, in particular, Lynn Lake, because of the closure of the Fox mine due to ore exhaustion, and Leaf Rapids, because the Ruttan mine has become uneconomic.

In response, government and industry are taking measures to discover and develop new mineral deposits and reduce production costs at existing mines. At Lynn Lake, the MacLellan gold mine has been developed by SherrGold Inc. and is staffed by approximately 160 former employees of the now closed Fox mine. The federal and provincial governments have provided assistance to this venture through the Canadian Jobs Strategy and the Manitoba Jobs Fund. Total investment had been approximately $55 million at the time the mine began producing, in August 1986. Production rate was 2 400 kg per year of gold.

At Leaf Rapids, Sherritt Gordon Mines Limited has substantially reduced production costs at its Ruttan mine. With the assistance of a provincial government loan and at a cost of $30 million, a deeper and higher-grade ore zone has been developed and mining more highly mechanized. Capacity has been expanded from 1.5 million tpy to 2.2 million tpy and reserves have been increased to 11.8 million t.

During 1986, the five-year $24.7 million Canada-Manitoba Mineral Development Agreement (MDA) entered its third year. The MDA is intended to strengthen and diversify mineral development and production in order to aid the Manitoba economy and northern mining communities in particular. Geoscience activities included: Precambrian geological investigations; mineral investigations; geophysical surveys; geochemical surveys and glacial prospecting; and geological compilation. Mining and mineral processing research activities are being conducted to improve productivity, mineral recovery and health and safety. Economic studies are being carried out to determine the commercial potential of industrial mineral deposits.

Despite the general slump that the mineral industry is experiencing, mineral exploration and development is providing some optimism for an improving economic outlook for northern Manitoba. In the Flin Flon area, development is proceeding on a new gold mine at Tartan Lake and a nickel-copper mine at Namew Lake, and exploration is active on several gold and base metal deposits. In the Snow Lake area, major zinc and precious metal finds are being explored at Morgan Lake. In the Lynn Lake area, wide-spread gold mineralization has been discovered and is being explored at various locations, including Farley Lake, Wasekwan Lake and Lynn Lake.

The future is brighter at the Thompson nickel mining and smelting operations because of continuing efforts to lower operating costs. This is being achieved mainly by conversion to bulk mining methods and the opening of the Thompson Pit, a new open-pit mine, in September. While employment levels will not be significantly affected by these investments, job security will be improved and the long-term viability of the Thompson operations enhanced.

Near Bissett, results are encouraging from an underground exploration program at the San Antonio gold mine, which has been shut down since May 1983. South of Bissett, near Lac du Bonnet, Tantalum Mining Corporation of Canada Limited (TANCO) has completed a plant at its Bernic Lake mine to produce ceramic-grade spodumene concentrate. The plant, which cost $6.4 million and employs approximately 40 people, exports all of its product.

The province and Canamax Resources Inc. have entered into an agreement to develop a potash mine near Russell. The initial phase calls for feasibility and market studies. The partners are attempting to interest foreign governments in providing equity investment and a market for the potash that would be produced.

SASKATCHEWAN

In 1986, the value of Saskatchewan's mineral production decreased by 32 per cent from 1985 to $2.57 billion. Of this amount, $1.27 billion was for crude petroleum, $447 million for uranium and $100 million for coal.

In northern Saskatchewan, exploration for gold and other precious metals remained intensive during 1986, particularly along the greenstone belt northeast of La Ronge. Among the most promising deposits are those located at Waddy Lake, Laonil Lake, Sulphide Lake and Mallard Lake. At Star Lake, the Saskatchewan Mining Development Corporation (SMDC) and partners are constructing a 220 tpd gold mine which is expected to begin producing in 1987 at a rate of 1 030 kg per year. Exploration and development should be further stimulated from the new Saskatchewan stock saving plan.

Farther north in the Athabasca Basin, uranium exploration, development and production are active despite the current low price for this commodity. There are many properties being actively investigated; one of the most significant is at Cigar Lake, where 110 000 t of uranium ore averaging 12 per cent U in the main zone and an additional 38 500 tU averaging 4 per cent U in an adjoining zone have been identified at a depth of 425m. Cigar Lake Mining Corporation, formed by the partners in the venture, has applied to federal and provincial regulatory bodies for approval of a plan to construct a shaft to test methods for mining this unique deposit. Another deposit being actively explored is the Eagle Point (North and South), which is estimated to contain 50 000 tU averaging 2.6 per cent U. Nearby to the south, Eldorado Nuclear Limited has commissioned its modified and expanded concentrator at Rabbit Lake and brought on stream its newly developed Collins Bay B-zone open-pit mine. The company intends to also develop the Collins Bay A and D zones and eventually the Eagle Point, which would extend the life of its operation into the late 1990s.

At Cluff Lake on the western side of the Athabasca Basin, Amok Ltd. is modifying its concentrator to reprocess radioactive residues produced during the initial years of the operation. The project will cost $2.6 million but is estimated to recover $3.8 million of uranium and $4.5 million of gold. Ore for the concentrator is currently being obtained from the Claude open-pit and the Dominique-Peter underground mines. Other zones are being explored for future development.

On the southeast edge of the Athabasca Basin, Key Lake Mining Corporation is operating its concentrator at full capacity of 4,600 tU per year. The company is stripping the Deilmann orebody to replace the Gaertner orebody, which was depleted by the end of 1986.

In southern Saskatchewan, the Cory demonstration plant of Potash Corporation of Saskatchewan (PCS), which utilises sodium sulphate and potassium chloride to produce potassium sulphate, has been undergoing tests during 1986. If this process is proven commercially feasible, a 300 000 tpy potassium sulphate plant is planned which would utilize sodium sulphate brine from Big Quill Lake. At the Lanigan operations of PCS, operators have been on strike over wages since March 10. Construction of the expansion, however, has continued and is now almost complete. Water infiltration of Saskatchewan potash mines has occurred several times in the past year, the most serious being at International Minerals & Chemical Corporation (Canada) Limited (IMCC)'s K-2 mine and Potash Company of America, Inc.'s mine near Patience Lake.

The third year of the five-year, $6.38 million Canada-Saskatchewan Mineral Development Agreement (MDA) commenced during 1986. Continuing activities include: geological investigations, particularly for gold and other precious metal mineralization in the La Ronge region; studies of geological relationships in the Kisseynew terrain; airborne gradiometric surveys in the north-central region; a lake sediment sampling program; and research on electrostatic separation of potash ore. Additional potash mining and processing technology activities to be conducted in cooperation with the industry are being initiated.

The threat of U.S. trade sanctions loomed over the Saskatchewan potash and uranium producers in 1986. However, the potash producers are hopeful that complaints by New Mexico protectionists will not be upheld because: the U.S. farm lobby will oppose any action that could cause higher prices; New Mexico producers are generally not competitive with Saskatchewan producers; and several Saskatchewan producers are owned by U.S. multinationals. Saskatchewan uranium producers are opposing pressures from U.S. producers and processers who wish to restrict the amount of uranium imported from Canada. Canadian producers are receiving support from some U.S. utilities, which would see their uranium costs increase dramatically if restrictions were applied.

Potash sales continued to fall since their partial recovery in 1984, as a result of low prices and reduced demand. This has caused producers to operate much below capacity and has induced intermittent layoffs. In an effort to expand offshore sales, Canpotex Limited inaugurated a new transportation system whereby potash is transported by rail to Minneapolis and then shipped to Caribbean and Central American markets. Canpotex Limited has also made its first sales offset arrangements with an Indian trading company for industrial equipment needed by the Saskatchewan producers. The efforts of Canpotex Limited, the Potash & Phosphate Institute of Canada and other agencies to promote potash in China and elsewhere are starting to show positive effects. This diversification has reduced the dependence on U.S. markets from about 70 per cent of total sales during the 1970s to currently about 60 per cent.

ALBERTA

In 1986, the value of mineral production in Alberta decreased by 35 per cent to $17.46 billion. Of this amount, $7.97 billion was for crude petroleum, $6.10 billion for natural gas, $1.76 billion for natural gas by-products, $874 million for sulphur and $438 million for coal.

Coal production, the principal mining activity in Alberta, is eclipsed in economic importance by the petroleum industry. However, it is important to the economy of a number of communities. The communities of Grande Cache, Edson and Hinton continue to be affected by intermittent layoffs at nearby coal mines because of weak offshore demand for thermal and coking coal.

The Smoky River coal mining operation of McIntyre Mines Limited at Grande Cache has been among the most affected as a result of diminished coal sales in recent years to Japanese steel mills, its traditional customers. The company continued to operate below capacity during 1986 because of oversupply and weak demand for its metallurgical coal. However, since 1981, the company has been reducing its operating costs to become more competitive. This has helped it obtain new contracts, the most important being with a consortium of Brazilian steel mills.

Mines supplying coal for domestic electric power generation continue to produce at near full capacity. A new mine is being constructed at Genesee, west of Edmonton, to feed the nearby electric power generating station of Edmonton Power, which is under construction. Weak offshore markets have resulted in deferral of several previously proposed coal projects.

Alberta's other major non-petroleum mineral commodity is elemental sulphur, which is produced as a by-product from sour natural gas. Demand has recovered since 1983 and prices have increased substantially. Inventories are falling as a result of the continuing deficit in world production over world consumption. Attempts are being made to develop very sour gas deposits primarily to recover sulphur.

Probably the most important event in 1986 for Alberta's coal and sulphur producers was the announcement by the federal government to deregulate the rail transportation system. The intentions of deregulation are to ultimately create a more competitive rail transportation system for bulk commodities and hence reduce delivery costs to markets. Coal producers would benefit by becoming more competitive in overseas markets and in southern Ontario markets, where coal is currently imported from the U.S.

In April, the Aluminum Company of America (Alcoa) and MPLC Canadian Magnesium Holdings Ltd. announced plans for a $375 million magnesium smelter near High River that would have employed over 400 people. However, this opportunity for a major boost to the regional economy received a major setback in October when Alcoa withdrew from the venture. MPLC is attempting to attract other partners. Production was planned to begin at 10 000 tpy of magnesium in 1988 and expand to 50 000 tpy by 1992.

BRITISH COLUMBIA

In 1986 the value of British Columbia's mineral production was $3.37 billion, down 4.9 per cent from 1985. Of this amount, $974 million was for coal, $667 million for copper, $257 million for crude petroleum, $431 million for natural gas and $170 million for zinc.

During 1986, new mines opened and exploration expenditures increased. Provincial government initiatives, such as the Critical Industries Commission, the Financial Assistance for Mineral Exploration (FAME) program and the Industrial Electricity Rate Discount Act; federal initiatives, such as the flow-through share provisions in the Income Tax Act; and joint federal-provincial initiatives such as the Canada-British Columbia Mineral Development Agreement (MDA) have contributed to a rejuvenation of the industry.

The Critical Industries Commission aided in the reopening of the Brenda and Bell mines and contributed to maintaining production at the Similkameen Mine. The Critical Industries Commission brings the mining companies, labour, municipalities and power companies to the table to examine innovative ways to lower costs of mines facing economic difficulties.

Under the one-year FAME program, $5 million was provided to directly stimulate mineral exploration. Grants were provided for exploration on properties with identified mineral potential, at developed mines to identify additional reserves, and for individual prospectors.

The province has a temporary surplus of electricity and the Industrial Electricity Rate Discount Act authorized discounts on electrical rates as an incentive for industrial expansion. Discounts were given to those mines aided through the Critical Industries Commissioner and also to the Endako mine, the Lornex mine-mill, the Island Copper mine and a new copper extraction plant for the Gibraltar mine.

In December, the province announced that the seven-year moratorium on uranium mining and exploration will be allowed to expire as scheduled on February 28, 1987.

Activities under the five-year, $10 million Canada-British Columbia Mineral Development Agreement (MDA) reached full strength in 1986. Further information on the MDA activities may be obtained from the MDA Manager, Ministry of Energy, Mines and Petroleum Resources, Parliament Buildings, Victoria, British Columbia, V8V 1X4.

NORTHERN CANADA

The value of mineral production in the Northwest Territories in 1986 was $789 million, down 8.6 per cent from 1985. Exploration expenditures estimated by the Department of Indian Affairs and Northern Development were up by about $10 million over last year to total between $30 and $35 million.

Production from the Faro Mine resumed during the year and, as a result, mineral production was up 205 per cent from 1985. The 1986 value of production was $183 million in the Yukon.

The Minister of Indian Affairs and Northern Development announced a Northern Mineral Policy near the end of the year. This policy has three objectives: to provide the industry with an atmosphere of certainty as to the government's intentions; to increase the industries' competitiveness by providing services comparable to those provided elsewhere in Canada and by minimizing government-imposed costs; and to encourage a dialogue between the mining industry, the public and both levels of government. With this policy the federal government recognizes the importance of mining in the north and has provided a framework for a dynamic mining sector, which will strengthen the northern economy.

In the Northwest Territories, a Land Use Planning process is now underway. A regional commission has been appointed for Lancaster Sound, and one for the Beaufort Sea-Mackenzie Delta is being selected. People in the region are being familiarized with the planning process, which is to be community based. The first plan is at least two years away, and will be subject to public scrutiny and debate before being submitted to the Minister of Indian Affairs and Northern Development for approval. In the Yukon, the Land Use Planning process is being discussed but is not yet underway.

The report of the Task Force to Review Comprehensive Claims Policy (the Coolican Task Force) was released and debated in 1986. The federal government announced a new comprehensive claims policy at year-end, which should resolve many of the problems inhibiting successful claim negotiations.

In the Yukon, the agreement in principle with the Council of Yukon Indians (CYI), which was reached in 1984, was not acceptable to a number of bands and negotiations have resumed.

In the Northwest Territories, at the Dene/Metis negotiations, a Wildlife Agreement was finally approved by the Department of the Environment. Negotiations on the amount of land to be included in the claim and land selection are proceeding. Exploratory discussions have also been held to determine how native people can benefit from resource development. At the Tungavik Federation of Nunavut (TFN) negotiations, exploratory discussion on a Nunavit Impact Review Board (NIRB) were held. In 1987, discussion of land quantum and land selection processes may begin.

In the western Arctic, some aspects of the implementation of the Inuvialuit Final Agreement that have proven, in practice, to be flawed are being re-examined.

In March 1986, a task force was set up under the authority of the Yukon Territory Water Board to review the existing management regime for the use of water in placer mining and provide recommendations to the Board. The Water Board submitted its recommendations to the Minister of DIAND in mid-July. Based on these recommendations the government is now devising a generally acceptable regulatory regime for placer mining.

The Canada-Yukon Mineral Development Agreement completed its second of four field seasons. Detailed mapping was done in the Rancheria Area and Dawson Range. Results of geochemical surveys in six map areas were released resulting in small staking rushes with each release. Additional map areas were sampled during the year. Projects including field trials of new placer mining technologies, settling pond testing, and laboratory research on heap leaching were conducted under the Placer Mining Program in 1986.

CANADA, PROVINCES AND TERRITORIES, LEADING MINERALS, 1985 AND 1986

	Value of production		Proportion of total	Change from 1985
	1985^{f}	1986P		
	($ million)		(per cent)	(per cent)
Newfoundland				
Iron ore	774.8	702.4	91.9	2.9
Asbestos	18.2	18.0	2.3	0.3
Zinc	41.0	8.2	1.1	-3.6
Total	869.7	764.1	100.0	-12.1
Prince Edward Island				
Sand and gravel	1.9	1.7	100.0	-10.5
Total	1.9	1.7	100.0	-10.5
Nova Scotia				
Coal	167.6	176.5	49.5	-2.0
Gypsum	47.2	50.8	14.2	-0.3
Sand and gravel	23.9	25.1	7.0	-0.3
Cement	21.0	20.4	5.7	-0.7
Total	325.3	356.6	100.0	9.6
New Brunswick				
Zinc	247.6	205.3	39.0	-9.6
Lead	39.4	51.4	9.7	2.0
Silver	48.9	51.0	9.7	0.1
Coal	31.6	26.7	5.0	-1.2
Total	508.8	526.0	100.0	3.4
Quebec				
Gold	419.3	482.9	21.2	2.6
Asbestos	223.6	232.9	10.2	0.3
Cement	183.7	200.7	8.8	0.7
Total	2,243.2	2,275.7	100.0	1.4
Ontario				
Nickel	930.7	815.8	17.0	-3.1
Copper	565.3	590.4	12.3	0.1
Uranium	552.5	476.4	9.9	-2.0
Zinc	351.7	375.1	7.8	0.3
Total	4,630.3	4,797.1	100.0	3.6
Manitoba				
Nickel	286.6	259.6	34.2	1.0
Copper	137.1	141.3	18.6	2.7
Petroleum	180.7	94.6	12.4	-8.5
Zinc	81.1	71.3	9.4	0.0
Total	862.1	758.3	100.0	-12.0

CANADA, PROVINCES AND TERRITORIES, LEADING MINERALS, 1985 AMD 1986 (Continued)

	Value of production		Proportion of total	Change from 1985
	1985f	1986P		
	($ million)		(per cent)	(per cent)
Saskatchewan				
Petroleum	2,370.0	1,269.7	49.3	-13.1
Potash	x	x	x	x
Uranium	449.5	447.3	17.3	5.5
Total	3,796.5	2,572.8	100.0	-32.2
Alberta				
Crude petroleum	15,207.3	7,970.2	45.6	-10.6
Natural gas	7,305.3	6,106.3	34.9	7.9
Natural gas by-products	2,740.3	1,762.1	10.0	-0.1
Sulphur, elemental	992.9	874.1	4.8	1.3
Total	27,029.6	17,462.7	100.0	-35.3
British Columbia				
Coal	1,018.6	974.8	28.9	0.2
Copper	594.9	677.7	20.1	3.3
Natural gas	539.6	431.2	12.8	-2.4
Petroleum	433.8	257.6	7.6	-4.6
Total	3,540.9	3,365.5	100.0	-4.9
Yukon Territory				
Gold	42.6	65.8	35.8	-35.2
Zinc	0.0	69.4	36.7	n.a.
Silver	13.0	16.8	9.1	-12.5
Sand and gravel	2.9	8.7	4.7	-0.1
Total	60.0	183.5	100.0	205.0
Northwest Territories				
Zinc	284.2	350.4	44.3	11.5
Gold	171.0	219.3	27.7	7.3
Lead	44.4	54.2	6.8	1.7
Total	864.6	789.8	100.0	-8.6
Canada				
Petroleum	18,417.8	9,719.1	28.7	-12.4
Natural gas	8,047.7	6,743.8	19.9	2.0
Natural gas byproducts	2,809.7	1,825.4	5.3	-0.9
Coal	1,845.1	1,716.0	5.0	0.9
Gold	1,219.6	1,715.3	5.0	2.3
Copper	1,466.9	1,567.9	4.6	1.4
Zinc	1,315.7	1,304.1	3.8	0.9
Iron ore	1,462.2	1,254.7	3.7	0.5
Nickel	1,217.3	1,075.4	3.1	0.4
Uranium	1,002.7	923.8	2.7	0.5
Total	44,733.5	33,854.3	100.0	-24.3

P Preliminary; x Confidential; f Final; n.a. Not applicable.

Canadian Reserves, Development and Exploration

A. LEMIEUX, G. MAROIS AND D.A. CRANSTONE

Table 1 illustrates the annually changing levels of Canadian reserves of seven major metals, in terms of the metal content of ore. These quantities were computed on the basis of information provided by mining companies. They pertain to ore tonnages that, as far as could be determined, were known at a level of assurance equivalent to "proven" (measured) and/or "probable" (indicated). Tonnages reported as "possible" (inferred) were not included. Table 2 shows a province-by-province breakdown for reserves as at January 1, 1986.

While the term "reserves" is widely used to refer to that part of mineral resources that, on a given date, is well delineated and considered economically mineable, the reserves in Table 1 and Table 2 are confined to those in producing mines and in deposits that have been committed for production. These reserves constitute the reliable core of information. For other deposits, where concrete steps have not been taken by companies to prepare them for mining, judgments by outsiders regarding economic mineability would not form a consistent basis for reporting reserves. The purpose of the "reserves" restrictions used here is to avoid such subjective judgments.

The quantities of reserves reported cannot, by themselves, give any indication of whether or not Canada might be running out of economically mineable minerals. Future production will draw not only on the 1986 reserves but also on additional reserves yet to be developed -- from discoveries, from extensions to known orebodies and from known but currently marginal or uneconomic material.

Canada has a large number of potential supply sources that are less assured than current reserves (Table 3). EMR's annual mineral bulletin[1] on Canadian mines deals with Canadian capability for metal production both from operating mines and from known deposits for which future production can be considered likely.

Measured in terms of metal contained in mineable ore, total national reserves of the seven nonferrous metals were generally on the rise up to 1981 (Table 1). Thereafter, the upward trend continued only in the case of gold; its reserves rose almost 70 per cent from 1981 to 1986. Since 1981, weak prices have caused a 30 per cent decline in reserves of molybdenum, about 20 per cent for lead and zinc, and some 15 per cent for copper, nickel, and silver.

From 1985 to 1986, Canadian reserves of gold rose about 7 per cent. Reserves of the other six metals declined by varying degrees: lead 10 per cent, copper and zinc 9 per cent, silver 8 per cent, and molybdenum 7 per cent. Reserves of nickel remained essentially unchanged. In the case of copper and silver, these one-year percentage declines were unusually large.

On a mine-by-mine and province-by-province basis, there continued to be considerable departures from national trends. Reserves in most mines change slightly from year to year, but on balance these cancel out in national totals. It is the relatively few mines with large changes in reserves that affect the overall direction of national trends. About one quarter of Canadian mines were responsible for 80 per cent of all net changes in reserves of the seven metals from 1985 to 1986.

The main causes of changes in reserves from 1985 to 1986 vary appreciably from metal to metal. The decrease in national reserves of silver occurred largely because companies removed from their mineral inventories entire deposits that no longer were judged to be mineable in the foreseeable future. For molybdenum, the reduction in reserves was due mainly to companies continuing to reassess downward the mineable tonnages at operating mines in light of poor price prospects. For lead and zinc, write-offs and write-downs of former

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[1] A. Lemieux, L.-S. Jen, G. Marois and D.A. Cranstone, "Canadian Mines: Perspective From 1986," Energy, Mines and Resources, Ottawa.

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reserves contributed about equally to decreases. For copper, reserves dropped for three reasons: write-offs, write-downs, and only partial replacement of tonnages produced in 1985.

Companies plan to close, by 1987, a number of the mines where write-downs of reserves took place during 1985. For other mines, reserves may have dropped only temporarily, and may well rise again in the next few years as a result of planned development programs.

Gold

Several new mining operations and new commitments to production raised the total of Canadian gold reserves, notably the Mount Skukum mine in the Yukon Territories (Total Erickson Resources Ltd. and AGIP Canada Ltd.), the Blackdome mine in British Columbia (M F C Mining Finance Corporation); the MacLellan mine in Manitoba (SherrGold Inc.); the Star Lake mine in Saskatchewan (Saskatchewan Mining Development Corporation, Starrex Mining Corporation Ltd. and Uranerz Exploration and Mining Limited); the Missanabie operation in Ontario (Anglo Dominion Gold Exploration Limited and Canreos Minerals (1980) Limited), the S-3 mine in Quebec (Campbell Resources Inc.), and the Cape Spencer mine in New Brunswick (Gordex Minerals Limited). Especially noteworthy are the additions to the reserves of proven and probable ore at a single producing operation -- Lac Minerals Ltd.'s Page-Williams mine at Hemlo, Ontario -- which were considerably larger than the combined additions at all of the above mines.

Copper

The data available up to the fall of 1986 show no notable net additions (gross additions minus production) to copper reserves at any producing mine in Canada during 1985. Noranda Inc. stopped counting as reserves the mineral inventories at its Little River joint venture (Heath Steele Mines Limited) in New Brunswick, at its Copper Mountain (sulphide) deposit in Quebec, and at its Granisle deposit in British Columbia. Production at these deposits had been suspended since at least 1983.

The largest single downward reassessment of copper reserves took place at Sherritt Gordon Mines Limited's Ruttan mine in Manitoba, contributing to a write-down of some $30 million. At Noranda's Brenda mine in British Columbia, reassessment of reserves resulted in a new mine plan reducing expected mine life to less than half of the previous estimate.

Nickel

Much of the nickel mined during 1985 in Ontario appears not to have been replaced with new reserves, but in Manitoba reserves were up slightly. Because total Canadian reserves are large compared to annual metal projection, irregular upkeep of reserves causes only small percentage variations in total reserves.

Lead, Zinc and Silver

Lead and zinc reserves were reduced largely because the mineral inventories at Noranda's Little River joint venture are no longer counted as reserves, and because of downward re-evaluation of reserves elsewhere. Some of the larger reductions took place at two of Cominco Ltd.'s operations -- the Sullivan mine in British Columbia and the Pine Point mine in the Northwest Territories -- and at the Selbaie mine (A-1 Zone) in Quebec, owned by BP Resources Canada Limited and Esso Resources Canada Limited.

One of the few prominent pluses to zinc and silver reserves in 1985 was the addition of the Abcourt-Barvue deposit in Quebec (Abcourt Mines Inc.).

Molybdenum

The main causes of the drop in Canadian reserves of molybdenum from 1985 to 1986 were: (i) the reassessment of reserves at Noranda's Brenda mine in British Columbia and at its Copper Mountain (sulphide) mine in Quebec, and (ii) the permanent closure of the Boss Mountain mine in British Columbia (suspended during 1982).

OUTLOOK

Only in the case of gold (and, to a lesser extent, zinc) will reserve levels likely change appreciably from 1986 to 1987 (Table 1). For gold, reserves may rise by as much as 10 per cent (for zinc about 4 per cent) because of new commitments to production.

Beginning in 1982, production at several mines was suspended indefinitely because it was no longer justifiable at prevailing low metal prices. Towards the end of 1986, mining at many of these deposits had either been resumed, or companies no longer counted them as part of their reserves, that is, as material that could be mined profitably in the foreseeable future. Companies continue to report "reserves" for some of the larger mines still suspended in late-1986 such as the Kitsault molybdenum mine (Amax of Canada Limited), the Goldstream mine (Noranda), and the Highmont mine (Teck Corporation) all in British Columbia; the Westarm mine in Manitoba (Hudson Bay Mining and Smelting Co., Limited; the Aquarius mine in Ontario (ASARCO Incorporated); and the Newfoundland Zinc mine (Teck and Amax). If reserves at these mines were no longer counted, the drop in national reserves would be significant only in the case of molybdenum -- over 35 per cent.

Reserves of base metals are unlikely to be built up substantially unless the market outlook and prices improve. In that case, some of the mineral material recently judged subeconomic might again be considered reserves; there is little doubt, however, that some of it will become irretrievable because of revised mining procedures. The outlook for new commitments in 1987 to create additional base-metal production capability for the longer term is not optimistic. Therefore, further declines in reserves can be expected in the coming years.

DEVELOPMENT

Figure 1(a) illustrates annual development expenditures since 1968. These have been consistently higher than the more widely publicized expenditures on exploration; the ratio of exploration to development expenditures is in the order of 0.6, Figure 1(b).

During 1985 a total of $817 million (preliminary) was spent on mine development. The level of development expenditures shows a slightly declining trend (in constant dollars) since the peak of 1981.

New commitments announced during 1986 to develop additional capability for metal, ore and concentrate production in Canada amounted to $550 million; 60 per cent of this was budgeted for gold development. This was a significant increase from the less than $200 million announced during 1985, but considerably less than in 1983-84, a two-year span when new commitments amounted to nearly $2 billion because of several megaprojects, the likes of which were not launched during 1986 and were not expected to be during 1987.

EXPLORATION

In 1985, the companies active in general and minesite exploration for metallic minerals in Canada numbered 700 to 800. Of these companies, only one in seven had one or more producing mines in Canada, but this relatively small group of producing companies accounted for about one-half of all expenditures on such exploration in Canada. Small independent exploration companies with no income from producing mines in Canada spent one-third of the total in 1985.

Figure 2 illustrates exploration activity in Canada expressed in terms of three yardsticks: total expenditures, new claims recorded and surface diamond drilling.[1] From 1984 to 1985, overall field exploration expenditures remained at the same level; the total area of claims staked fell slightly; and surface diamond drilling rose by 13 per cent.

Exploration Expenditures. The surge in field exploration expenditures from $365 million in 1983 to $476 million in 1984 levelled off in 1985, again totalling $476 million.

The most active areas remained Quebec -- leading all other provinces in exploration expenditures --, Ontario and British Columbia. In 1985, 65 per cent of field exploration expenditures in Canada were made in these three provinces.

Preliminary indications are that, in 1986, exploration activity rose most significantly in Quebec. In late-1986, tax incentives for exploration in Quebec were reduced to match those available elsewhere in Canada. This may dampen the vigor of exploration activity in Quebec somewhat, but recent exploration successes in the province and the momentum of ongoing programs may keep up the high levels of exploration activity for some time even without the special incentives.

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[1] Oil and gas are not covered by these mineral exploration statistics. In the case of new claims recorded, coal is excluded as well.

Flow-through shares continued to gain favour as a means of maintaining exploration activity at a time when industry cash flows were low. Capital raised through flow-through shares increased from $34 million in 1983 to $253 million in 1985; preliminary estimates suggest that it reached about $500 in 1986 and may be higher still in 1987. Flow-through share tax benefits apply not only to field expenditures but also to additional related overhead expenditures that generally amount to about one-quarter of field expenditures.

Claim Staking. The area staked in 1985 was up sharply from 1984 in Newfoundland, Nova Scotia, New Brunswick and, most notably, in Saskatchewan where it was five times as large as in 1984, but these increases were more than offset by decreases in Ontario, Manitoba, British Columbia and the Yukon.

The area staked in 1986 was some 25 per cent larger than in 1985, because of substantial increases in Quebec, Ontario and Manitoba and moderate increases in the Northwest Territories and Yukon. The area of claims staked in Newfoundland and British Columbia in 1986 was about the same as in 1985. Staking in Saskatchewan was down by some 25 per cent, but it was still well above that of 1984. In New Brunswick, the area staked, which had been up substantially in 1985, fell to a level only slightly above that of 1984.

Diamond Drilling. The total amount of metres drilled nationwide was 10% higher in 1985 than in 1984; it rose 63% in Ontario, 33% in Newfoundland and 17% in Quebec.

Depending on the province, drilling expenditures represented 35-50 per cent of total field expenditures.

Exploration Targets. Gold was the prime exploration target in all regions except in Saskatchewan and Alberta. In Saskatchewan, more was spent on the search for uranium and, in Alberta, more on coal exploration than on all non-fuel minerals together.

Almost two-thirds of Canadian mineral exploration expenditures in 1985 was aimed at gold. About the same proportion of the 30 mineral deposits discovered in Canada during 1985 (a typical annual discovery rate over the last 25 years) were gold deposits.

Foreign companies (mostly government agencies) accounted for about 60 per cent of the $23 million spent on Canadian uranium exploration in 1985. There were no oil company expenditures on uranium exploration in 1985, in contrast to tens of millions of dollars a few years ago.

Notable Canadian mineral discoveries of 1985 are Beaverdam (gold) in Nova Scotia; Elmtree (gold) in New Brunswick; Isle Dieu (zinc-copper-silver), Ribago-Silidor-Waite-Beauchastel (gold), and Estrades (gold-zinc-silver-copper) in Quebec; Golden Patricia (gold), Matheson East (gold), and a new silver discovery 2.5 km from the main shaft of the Langis mine in Ontario; Namew Lake (nickel-copper-platinum metals) in Manitoba; Rod and Rod South (gold) in Saskatchewan; Tel (gold) and Lara (gold-silver-zinc-copper-lead) in British Columbia; and Cass (gold) in the Northwest Territories. In the Yukon, known tonnages were greatly enlarged at the previously known Brown-McDade (gold-silver) and Mount Hundere (zinc-lead-silver) deposits.

A joint federal-provincial survey of exploration field expenditures shows the following distribution of expenditure for 1985, by commodity groups:

	Per cent
Precious metals (primarily (gold; some silver and platinum group metals)	67
Copper, zinc, lead and nickel	20
Other metals	7
Nonmetallic minerals	6

Money spent in the search for gold has risen -- as a percentage of total mineral exploration expenditures for new deposits in Canada -- from 4% in 1975 to 10% in 1979, to 20% in 1981, to over 50% in 1984, to about 60% in 1985, and the percentage is expected to rise still further.

Promising Deposits. The rate of discovery of mineral deposits in Canada has been at a high level for many years. Table 3 lists almost 150 deposits that, in late-1986, appeared particularly promising. Selection was based on the evaluation of exploration efforts made to date, tonnages, metal grades, the availability of infrastructure, and the probable mining methods. Each deposit selected as promising for future production was rated on a scale of 1 to 3, with 3 signifying the greatest relative promise. Because the information available on individual deposits varies greatly, this rating is largely subjective. The outlook for a continuation of weak base-metal prices led us to remove some deposits previously considered promising, but we added a comparable number of gold deposits. Other deposits that may be widely regarded as promising are not included because the owners have not released sufficient information or because the deposit is not yet adequately outlined.

TABLE 1

CANADIAN RESERVES, 1978-86 AND ESTIMATES FOR 1987

Quantities of Metals Contained in Proven and Probable Mineable Ore[1]
In Operating Mines and Deposits Committed for Production as at January 1st

Metal	Units[2]	1978	1979	1980	1981	1982[4]	1983[4]	1984[4]	1985[4]	1986[4]	1987[4,5]	1987[5,6]
Copper	000 t	16 471	15 840	16 405	16 831	15 815	17 022	16 163	15 788	14 384	14 400	14 100
Nickel	000 t	7 389	7 070	7 245	8 304	8 013	7 581	7 339	7 222	7 047	7 000	7 000
Lead	000 t	8 934	8 911	9 557	10 119	10 244	9 029	9 048	8 887	8 012	8 000	8 000
Zinc	000 t	26 908	26 452	28 635	29 436	29 505	26 077	26 371	26 218	23 747	24 600	24 300
Molybdenum	000 t	384	462	554	550	514	494	446	393	364	360	230
Silver	t	29 085	29 398	31 564	33 614	32 154	31 381	31 359	31 300	28 801	29 200	29 100
Gold[3]	kg	366 421	409 582	540 493	769 889	842 215	837 707	1 166 677	1 225 434	1 306 814	1 426 500	1 422 000

[1] No allowance is made for losses in milling, smelting and refining. [2] One tonne = 1.1023113 short tons. One kilogram = 32.150746 troy ounces. [3] Excludes metal in placer deposits. [4] Includes metal in mines where production has been suspended indefinitely. [5] Includes metal in deposits committed for production at year-end 1986. [6] Excludes metal in mines where production has been suspended indefinitely.

TABLE 2

CANADIAN RESERVES BY PROVINCE

Quantities of Metals Contained in Proven and Probable Mineable Ore[1]
In Operating Mines and Deposits Committed for Production as at January 1, 1986[2]

Metal	Units[3]	Nfld.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	B.C.	Y.T.	N.W.T.	Canada[5]
Copper	000 t	-	62	340	680	6 292	558	14	6 438	-	-	14 384
Nickel	000 t	-	-	-	-	5 215	1 832	-	-	-	-	7 047
Lead	000 t	-	-	3 866	-	156	16	1	1 451	1 403	1 120	8 012
Zinc	000 t	122	104	9 471	656	3 882	641	10	2 789	2 109	3 963	23 747
Molybdenum	000 t	-	-	-	1	14	-	-	349	-	-	364
Silver	t	-	-	10 301	1 286	7 540	767	11	6 792	1 970	134	28 801
Gold[4]	kg	-	-	1 555	215 468	845 389	38 864	4 225	131 307	8 443	61 562	1 306 814

[1] No allowance is made for losses in milling, smelting and refining. [2] Includes metal in mines where production has been suspended indefinitely. [3] One tonne = 1.1023113 short tons. One kilogram = 32.150746 troy ounces. [4] Excludes metal in placer deposits. [5] May not balance due to rounding at the provincial level.
- Nil.

TABLE 3

TONNAGES AND GRADES OF ADDITIONAL DEPOSITS CONSIDERED IN LATE-1986 MOST PROMISING FOR FUTURE PRODUCTION

1. RATING: Individual deposits have been assigned one, two, or three stars on the basis of (a) state of exploration and development, (b) tonnage and grade reported publicly, (c) available infrastructure, and (d) mining method and other factors affecting viability. In this judgment of relative merit, three stars imply the highest promise.
2. TONNAGE and GRADE: As reported by a direct source or, where necessary from the secondary source that appeared to be the best informed. Imperial units reported were converted to metric units and rounded.
3. Where two or more companies are identified with a deposit, the first is usually the operator.

COMPANY AND DEPOSIT	RATING	TONNAGE	GRADE						
			Cu	Ni	Pb	Zn	Mo	Ag	Au
		tonnes[1]	%	%	%	%	%	g/t	g/t
NEWFOUNDLAND									
Hope Brook Gold Inc.									
Hope Brook (Chetwynd)									
- open-pit	***2	686 000	-	-	-	-	-	-	4.44
- underground	***2	9 703 200	-	-	-	-	-	-	4.10
Dolphin Explorations Ltd.									
Mascot Gold Mines Limited									
Cape Ray	**	630 500	-	-	-	-	-	14.98	8.02
NOVA SCOTIA									
Greenstrike Gold Corp.									
Pan East Resources Inc.									
Fifteen Mile Stream	*	196 100	-	-	-	-	-	-	7.5
Inco Limited									
Northumberland Mines Limited									
Cochrane Hill mine	***	907 200	-	-	-	-	-	-	11.0
Seabright Resources Inc.									
Beaver Dam	***	1 420 000	-	-	-	-	-	-	9.9
Forest Hill mine	**	245 425	-	-	-	-	-	-	9.90
Gays River mine	*	981 400	-	-	5.35	9.42	-	-	-
Oldham & Montague - tailings	**	339 000	-	-	-	-	-	-	1.66
NEW BRUNSWICK									
Lacana Mining Corporation									
Elmtree Brook	*	363 000	-	-	-	-	-	-	5.1
Lincoln Resources Inc.									
Placer Development Limited									
Third Portage Lake (Restigouche)	*	2 721 600	0.34	-	4.5	6.0	-	86.0	-

Northumberland Mines Limited									
Kennco Explorations, (Canada) Limited									
Murray Brook - gossan	***	1 723 600	-	-	-	-	-	45.46	1.34
Noranda Exploration Company, Limited									
Conwest Exploration Company Limited									
Half-Mile Lake	**	12 338 000	0.19	-	2.52	7.50	-	30.9	-
QUEBEC									
Aabarock Mining Resources Inc.									
Louvem Mining Company Inc.									
Sullivan Mines Inc.									
Courvan	*	367 400	-	-	-	-	-	-	4.66
Amberquest Resources Ltd.									
New Goldcore Ventures Ltd.									
Cambior inc.									
Rouyn-Merger mine	*	466 300	-	-	-	-	-	-	6.1
Audrey Resources Inc.									
Corporation Falconbridge Copper									
Mobrun (Dufresnoy) - underground	***	1 071 422	0.84	-	-	3.59	-	36.11	5.12
- open-pit	***	285 420	0.68	-	-	2.64	-	26.21	1.66
Augmitto Explorations Limited									
Durbar (Beauchastel)	**	1 315 400	-	-	-	-	-	-	5.5
Aumine Exploration									
Sullivan Mines Inc.									
Goldstack Resources Ltd.									
Dubuisson (Malartic Goldfields)	**	788 500	-	-	-	-	-	-	6.14
Aunore Resources Inc.									
Nova Beaucage Mines Limited									
Peel-Elder	**	587 550	-	-	-	-	-	-	6.24
Aur Resources Inc.									
Orenada - Zone 4 (Bourlamaque)	**	671 300	-	-	-	-	-	-	5.5
Belmoral Mines Ltd.									
Wrightbar Mines Limited									
Wrightbar (Bourlamaque)	**	116 600	-	-	-	-	-	-	7.9
Cambior inc.									
Pascalis - Sud No. 1	*	350 000	-	-	-	-	-	-	6.17
Campbell Resources Inc.									
Devlin mine (Obalski)	*	1 134 000	2.25	-	-	-	-	-	-
Main mine (Obalski) - pillar	*	2 015 000	0.85	-	-	-	-	-	0.10

COMPANY AND DEPOSIT	RATING	TONNAGE	GRADE						
			Cu	Ni	Pb	Zn	Mo	Ag	Au
		tonnes¹	%	%	%	%	%	g/t	g/t
QUEBEC (cont'd)									
Campbell Resources Inc. Meston Lake Resources Inc. Joe Mann mine (Rohault)	***	499 000	0.40	-	-	-	-	-	7.17
Cogesco Mining Resources Inc. Aur Resources Inc. Nolartic mine (Vassan)	*	781 000	-	-	-	-	-	-	4.5
Corporation Falconbridge Copper Ansil (Duprat)	***	2 100 000	7.0	-	-	0.5	-	24.0	1.7
Dassen Gold Resources Ltd. Russian Kid (Dasserat)	**	1 220 100	-	-	-	-	-	-	6.9
Dome Mines, Limited Western Quebec Mines Co. Ltd. K-Zone Extension (Vassan)	*	1 147 600	n.a.	-	-	-	-	-	4.11
D'Or Val Mines Ltd. Beacon No. 2 (Louvicourt)	***	312 000	-	-	-	-	-	-	7.9
Dumagami Mines Limited Dumagami mine	***2	4 955 000	-	-	-	-	-	n.a.	4.59
Eastern Mines Ltd. Silver Sceptre Resources Ltd. Hosco-Heva									
- Hosco	**	1 144 440	-	-	-	-	-	-	4.11
- Heva		1 806 000	-	-	-	-	-	-	5.62
Falconbridge Limited Callahan (Dubuisson)	**	2 300 000	-	-	-	-	-	-	6.51
Goldex Mines Limited Probe Mines Limited Dalton/Probe (Dubuisson)	*	776 600	-	-	-	-	-	-	7.17
Inco Limited Golden Knight Resources Inc. Golden Pond - Main zone	**	2 630 800	-	-	-	-	-	-	7.2
- East zone	***	3 628 700	-	-	-	-	-	-	6.9
- West zone	**	1 814 300	-	-	-	-	-	-	6.9
Louvem Mining Company Inc. Pascalis-Nord (Pascalis)	**	233 500	-	-	-	-	-	-	6.8
Noranda Inc. La Gauchetière	*	1 245 600	0.87	-	-	4.28	-	16.5	-

Noranda Inc. Cambior inc. Cogesco Mining Resources Inc. Ribago-Silidor	**	344 300	-	-	-	-	-	-	6.2
Noranda Inc. Isle Dieu Mattagami Mines Limited Isle Dieu	***2	2 100 000	1.23	-	-	22.4	-	95.0	-
Noranda Inc. Muinsco Resources Limited New Insco mine (Hébécourt)		792 900	2.59	-	-	-	-	20.6	-
Northgate Mines Inc. Bateman Bay mine (McKenzie)	**	678 700	1.76	-	-	-	-	13.71	3.38
Norbeau Mines Inc. Norbeau mine (McKenzie)	**	916 260	-	-	-	-	-	-	7.2
NSR Resources Inc. Rand Malartic Mines, Limited Cogesco Mining Resources Inc. Rand Malartic	*	262 530	-	-	-	-	-	-	5.3
Perron Gold Mines Ltd. Noranda Exploration Company, Limited Cogesco Mining Resources Inc. Sleeping Giant (Chaste)	**	1 360 800	-	-	-	-	-	-	9.6
Placer Development Limited Eastmain River		1 333 600	0.22	-	-	-	-	12.3	10.3
Quebec Explorers Corporation Ltd. Cogesco Mining Resources Inc. Dubuisson	**	399 160	-	-	-	-	-	-	7.2
Ressources Minières Rouyn Inc. Lac Fortune	*	246 950	-	-	-	-	-	-	5.68
Ressources Minières Rouyn Inc. Lac Minerals Ltd. Francoeur mine	**	656 000	-	-	-	-	-	-	6.62
Wasamac mine - pillar	**	1 088 600	-	-	-	-	-	-	2.85
Sullivan Mines Inc. Aiguebelle Resources Inc. Cambior inc. Eldrich-Flavel (Duprat)	**	974 900	-	-	-	-	-	-	6.36

COMPANY AND DEPOSIT	RATING	TONNAGE	GRADE Cu	Ni	Pb	Zn	Mo	Ag	Au
		tonnes[1]	%	%	%	%	%	g/t	g/t
QUEBEC (cont'd)									
Sullivan Mines Inc.									
Bachelor Lake Gold Mines Inc.									
Flordin Mines Limited									
Flordin (Desjardins)	*	471 000	-	-	-	-	-	-	6.65
Sullivan Mines Inc.									
Dominion Explorers Inc.									
Croinor (Pershing)	*	386 000	-	-	-	-	-	-	5.48
Teck Corporation									
Golden Hope Resources Inc.									
Golden Group Explorations Inc.									
Estrades	***								
- Main zone		889 683	0.62	-	1.04	9.03	-	163.5	6.2
- Middle zone		848 463	0.85	-	-	5.59	-	75.8	5.1
- East zone		602 145	0.99	-	-	7.51	-	68.6	1.0
Yorbeau Resources Inc.									
Ellison - A zone	**	744 000	-	-	-	-	-	-	6.9
Yorbeau Resources Inc.									
Campbell Resources Inc.									
ERG Resources Inc.									
Astoria (Rouyn)	**	1 142 740	-	-	-	-	-	-	6.2
ONTARIO									
American Barrick Resources Corporation									
Holt-McDermott mine	***2	2 721 500	-	-	-	-	-	-	6.5
Canamax Resources Inc.									
Bruneau Mining Corporation									
Clavos (German & Stock)	*	426 400	-	-	-	-	-	-	7.27
Canamax Resources Inc.									
Consolidated CSA Minerals Inc.									
Bell Creek mine	***2	1 174 900	-	-	-	-	-	-	6.5
Canamax Resources Inc.									
Kremzar Gold Mines, Limited									
Kremzar	***	997 900	-	-	-	-	-	-	8.06
Canamax Resources Inc.									
Procan Exploration Company Limited									
Matheson - East zone	**	524 350	-	-	-	-	-	-	8.43

Citadel Gold Mines Inc. Surluga-Pango mine	***	1 451 500	-	-	-	[illegible]	-	-	4.8
Consolidated Professor Mines Limited Duport mine	***	1 360 800	-	-	-	-	-	-	11.7
Corporation Falconbridge Copper Zenmac Zinc Ltd. Winston Lake mine	***2	3 100 850	1.01	-	-	15.9	-	30.3	1.05
Dome Mines, Limited Campbell Red Lake Mines Limited Dona Lake	***	1 180 000	-	-	-	-	-	-	7.5
Dome Mines, Limited Inco Limited Esso Minerals Canada Lacana Mining Corporation Snoppy Lake	*	1 995 800	-	-	-	-	-	-	8.2
Echo Bay Mines Ltd. Nuinsco Resources Limited Lockwood Petroleum Inc. Cameron Lake	**	1 474 200	-	-	-	-	-	-	5.5
Emerald Lake Resources Inc. Place Resources Corporation Golden Rose	***	1 747 700	-	-	-	-	-	-	7.00
ERG Resources Inc. Pamour Inc. Timmins - tailings		132 000 000	-	-	-	-	-	-	0.51
Freegold Recovery Inc. Campbell Red Lake Mines Limited Balmerton - tailings	***	4 082 300	-	-	-	-	-	-	1.75
Freegold Recovery Inc. Kirkland Lake - tailings	*	534 300	-	-	-	-	-	-	0.7
Getty Resources Limited Davidson Tisdale Mines Limited Tisdale	***	748 400	-	-	-	-	-	-	12.34
Golden Shield Resources Ltd. Mirado Nickel Mines Limited Mirado mine (Cathroy-Larder)	***2	450 425	-	-	-	-	-	-	11.3
Goldpost Resources Inc. New Kelore Mines Limited Hislop	*	362 800	-	-	-	-	-	-	5.8
Intex Mining Company Limited Frankfield Explorations Ltd. Tully	**	272 100	-	-	-	-	-	-	8.2

COMPANY AND DEPOSIT	RATING	TONNAGE	GRADE Cu	Ni	Pb	Zn	Mo	Ag	Au
		tonnes[1]	%	%	%	%	%	g/t	g/t
ONTARIO (cont'd)									
Jamie Frontier Resources Inc. Pipestone Bay	*	72 660	-	-	-	-	-	-	17.04
Kerr Addison Mines Limited Eldor Resources Limited Larder Lake	**	737 300	-	-	-	-	-	-	5.96
Mono Gold Mines Inc. Bannockburn	**	226 740	-	-	-	-	-	-	15.29
McFinley Red Lake Mines Limited Phoenix Gold Mines Limited McFinley (Bateman)	**	237 700	-	-	-	-	-	-	9.3
Muscocho Explorations Limited Jerome Gold Mines Corporation Jerome	*	528 900	-	-	-	-	-	-	6.9
Muscocho Explorations Limited Flanagan McAdam Resources Inc. Windarra Minerals Ltd. Mishibishu Lake	**	587 650	-	-	-	-	-	-	7.5
Muscocho Explorations Limited McNellen Resources, Inc. Magino	**	967 800	-	-	-	-	-	-	8.6
Noranda Exploration Company, Limited Band-Ore Gold Mines Limited Shebandowan	*	589 700	-	-	-	-	-	7.71	4.73
Norben Gold Resources Inc. Pancontinental Mining (Canada) Ltd. Northern Empire - dump		149 700	-	-	-	-	-	-	1.92
Novamin Resources Inc. Eldor Resources Limited Cadieux	*	725 700	-	-	1.2	11.2	-	-	-
Novamin Resources Inc. First General Mine Management & Gold Corp. Rundle	*	156 580	-	-	-	-	-	-	8.85
Orofino Resources Limited Orofino mine	**	240 500	-	-	-	-	-	-	8.2

Orofino Resources Limited Groundstar Resources Limited Orostar mine (Davis)	***2	57 100	0.82	-	-	-	-	-	7.0
Silver Lake Resources Inc. Silverside Resources Inc. North Cobalt	*	99 800	-	-	-	-	-	1029.0	-
St. Andrew Goldfields Ltd. Quebec Sturgeon River Mines Limited Stock	***	667 350	-	-	-	-	-	-	4.62
St. Andrew Goldfields Ltd. Esso Minerals Canada Taylor	**	989 000	-	-	-	-	-	-	4.32
St. Joe Canada Inc. Golden Patricia	**	700 000	-	-	-	-	-	-	20.0
Vedron Limited Belmoral Mines Ltd. Vedron-Romfield	***	907 200	-	-	-	-	-	-	6.9
Zahavy Mines Limited Getty Resources Limited Favourable Lake	*	646 800	-	-	-	-	-	165.6	8.6
MANITOBA									
American Barrick Resources Corporation Zenco Resources Inc. Squall Lake - near surface	*	680 400	-	-	-	-	-	-	3.0
Cobra Emerald Mines Limited Comiesa Corporation Nor-Acme - tailings	***2	227 000	-	-	-	-	-	-	11.11
Granges Exploration Ltd. Abermin Corporation Tartan Lake - Main zone	***	464 500	-	-	-	-	-	-	11.97
Hudson Bay Mining and Smelting Co., Limited Namew Lake	**	2 590 000	0.9	2.44	-	-	-	-	-
Nor-Acme Gold Mines, Limited Nor-Acme mine	*	2 527 450	-	-	-	-	-	-	5.5
Pioneer Metals Corporation Puffy Lake mine	***2	1 179 300	-	-	-	-	-	17.1	7.20
San Antonio Resources Inc. Cassiar Mining Corporation San Antonio mine	*	1 322 290	-	-	-	-	-	-	7.99

COMPANY AND DEPOSIT	RATING	TONNAGE	GRADE						
			Cu	Ni	Pb	Zn	Mo	Ag	Au
		tonnes[1]	%	%	%	%	%	g/t	g/t
SASKATCHEWAN									
Golden Rule Resources Ltd. Comaplex Resources International Ltd. Tower Lake	**	1 360 800	-	-	-	-	-	-	3.4
Golden Rule Resources Ltd. Saskatchewan Mining Development Corporation (SMDC) Weedy Lake	**	998 000	-	-	-	-	-	-	4.46
Granges Exploration Ltd. Saskatchewan Mining Development Corporation Bigstone Lake	*	3 596 080	1.87	-	-	1.1	-	9.9	0.45
		1 270 600	2.91	-	-	-	-	-	-
		337 400	-	-	-	11.2	-	-	-
Placer Development Limited Claude Resources Inc. Seabee (Laonil Lake)	***	1 000 000	-	-	-	-	-	-	11.0
Placer Development Limited Waddy Lake Resources Inc. Komis	**	1 179 300	-	-	-	-	-	-	4.18
Royex Gold Mining Corporation Canadian Premium Resource Corporation Mahogany Minerals Resources Inc. Jolu	***	834 600	-	-	-	-	-	-	20.9
Saskatchewan Mining Development Corporation Claude Resources Inc. Jojay	**	288 500	-	-	-	-	-	-	8.2
Vista Mines Inc. Bootleg mine	*	166 800	-	-	-	-	-	-	10.3
BRITISH COLUMBIA									
Afton Operating Corporation Cominco Ltd. Imperial Metals Corporation Ajax		9 000 000	0.5^e	-	-	-	-	n.a.	n.a.

Cendorado Mines Ltd. Hedley - tailings	**	1 525 000	-	-	-	-	-	0.45^{e}	1.41
Consolidated Cinola Mines Ltd. (now City Resources (Canada) Limited) Graham Island	*	6 350 300	-	-	-	-	-	-	3.43
Curragh Resources Corporation Hudson's Bay Oil and Gas Company Limited (HBOG) Cirque	*	21 700 000	-	-	2.7	9.0	-	57.0	-
Corporation Falconbridge Copper Pacific Cassiar Limited Chu Chua	*	2 500 000	2.0	-	-	0.5	-	9.0	0.5
Corporation Falconbridge Copper Rea Gold Corporation Adams Lake	*	242 870	0.52	-	2.1	2.2	-	72.0	6.5
Dolly Varden Minerals Inc. North Star, Torbrit and Wolf	**	775 000	-	-	0.53	0.82	-	316.11	-
Energex Minerals Ltd. Toodoggone	*	239 500	-	-	-	-	-	-	8.51
Esso Minerals Canada Sumac Mines Ltd. Kutcho Creek	*	15 700 000	1.69	-	-	2.16	-	27.7	0.38
Invermay Resources Inc. Ruth Vermont mine	*	272 200	-	-	4.8	5.4	-	40.0	-
Mascot Gold Mines Limited Nickel Plate - open-pit - underground	***2	6 441 000 1 385 250	- -	- -	- -	- -	- -	- -	5.1 5.5
Mascot Gold Mines Limited Bralorne Resources Limited E & B Explorations Ltd. Bralorne-Pioneer mines	***	941 200	-	-	-	-	-	-	9.3
Mascot Gold Mines Limited Golden North Resource Corporation Canty et al.		997 900	-	-	-	-	-	-	4.5
McAdam Resources Inc. Muscocho Explorations Limited Spud Valley mine (Zeballos)	**	389 200	-	-	-	-	-	-	8.6
Newhawk Gold Mines Ltd. Lacana Mining Corporation Granduc Mines, Limited Sulphurets	**	1 437 112	-	-	-	-	-	783.6	11.52

COMPANY AND DEPOSIT	RATING	TONNAGE	GRADE Cu	 Ni	 Pb	 Zn	 Mo	 Ag	 Au
		tonnes[1]	%	%	%	%	%	g/t	g/t
BRITISH COLUMBIA (cont'd)									
New Privateer Mine Limited									
Zeballos mine (Privateer)	**	447 200	-	-	-	-	-	-	13.5
Northair Mines Ltd.									
BP Canada Inc.									
Rio Algom Limited									
Willa	**	495 800	0.87	-	-	-	-	9.6	6.24
North American Metals Corp.									
Chevron Minerals Ltd.									
Golden Bear	*	1 025 100	-	-	-	-	-	-	13.0
Regional Resources Ltd.									
Canamax Resources Inc.									
Procan Exploration Company Limited									
Midway	***	1 185 000	-	-	7.0	9.6	-	410.0	n.a.
Serem Inc.									
Agnico-Eagle Mines Limited									
Sudbury Contact Mines, Limited									
Lawyers	***	940 800	-	-	-	-	-	259.9	7.2
Teck Corporation									
Pacific Cassiar Limited									
Porter-Idaho and Prosperity	***	826 500	-	-	2.0^{e}	3.0^{e}	-	669.0	-
Teeshin Resources Ltd.									
Canadian-United Minerals Inc.									
Dome Mountain	**	217 700	-	-	-	-	-	79.0	15.70
Trader Resource Corp.									
Tel	**	293 870	-	-	-	-	-	n.a.	23.8
Westmin Resources Limited									
British Silbak Premier Mines Limited									
Silbak Premier - open-pit	***	5 776 055	-	-	-	-	-	86.40	2.06
- underground		463 000	-	-	1.13	3.70	-	37.64	4.15
Westmin Resources Limited									
Tournigan Mining Explorations Ltd.									
Big Missouri	*	2 266 200	-	-	-	-	-	32.57	2.57
YUKON TERRITORY									
Abermin Corporation									
Cassiar Mining Corporation									
Jason	*	9 800 000	-	-	10.52	8.14	-	135.0	-

Canamax Resources Inc. Mt. Hundere	**	1 995 800	-	-	8.7	14.1	-	72.0	-
Canamax Resources Inc. Pacific Trans-Ocean Resources Ltd. Peel and Ridge - oxide	***	390 100	-	-	-	-	-	-	17.49
Chevron Minerals Ltd. B.Y.G. Natural Resources Inc. Mt. Nansen - Brown McDade zone	**	725 800	-	-	-	-	-	69.0	7.89
Curragh Resources Corporation DY		21 000 000	-	-	5.6	6.9	-	85.03	-
NORTHWEST TERRITORIES									
Canuc Resources Inc. Coronation Gulf	*	760 200	-	-	-	-	-	-	7.21
Discovery Mines Limited Hydra Explorations Limited Indin Lake (Johnsby)	*	11 800 000	-	-	-	-	-	-	2.91
Giant Bay Resources Ltd. Gordon Lake		100 000	-	-	-	-	-	-	21.2
Kidd Creek Mines Ltd. Izok Lake	*	11 023 000	2.8	-	1.4	13.77	-	70.3	-
Noranda Exploration Company, Limited Getty Resources Limited Tundra (Courageous Lake)	**	635 000	-	-	-	-	-	-	12.3
Terra Mines Ltd. Bullmoose	*	146 300	-	-	-	-	-	-	15.39
Treminco Resources Ltd. Goldrich Resources Inc. Tom mine (Yellowknife)	***2	14 000	-	-	-	-	-	-	13.1

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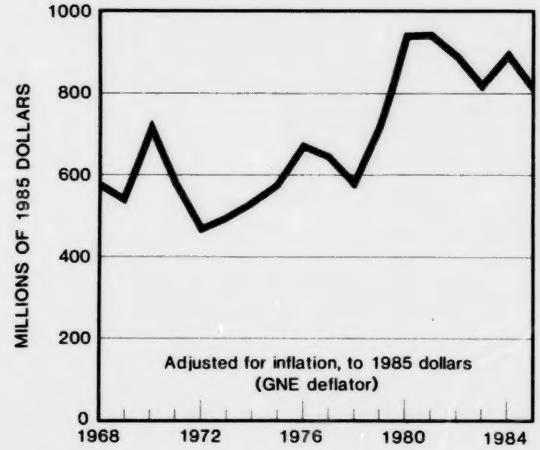
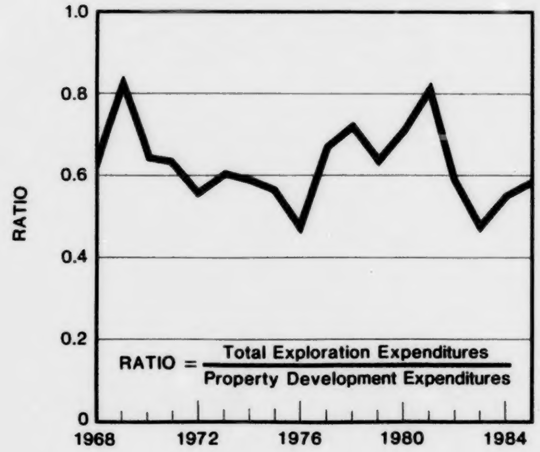
[1] One tonne = 1.1023113 short tons; 1 gram per tonne (g/t) = 0.02916668 troy ounces per short ton. [2] Committed for production after January 1, 1986. Therefore not included in Tables 1 and 2.
n.a. Not available; - Nil; e Author's estimate.

Figure 1



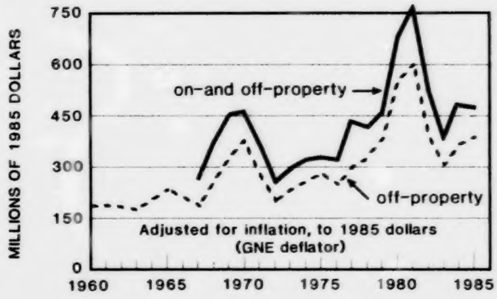
(a)
EXPENDITURES ON PROPERTY DEVELOPMENT



(b)
EXPLORATION VS DEVELOPMENT

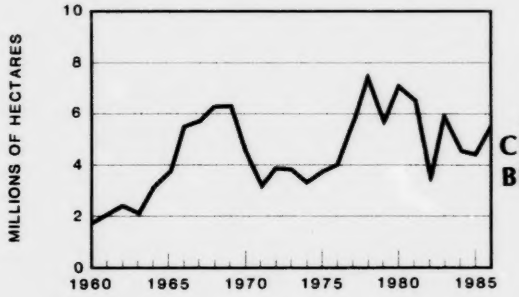
Figure 2

MEASURES OF EXPLORATION ACTIVITY

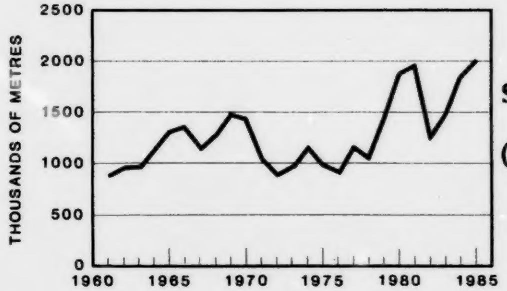


Adjusted for inflation, to 1985 dollars
(GNE deflator)

(a)
EXPENDITURES ON MINERAL EXPLORATION
(All minerals except oil and gas)



(b)
AREA OF MINING CLAIMS AND CLAIM BLOCKS RECORDED



(c)
SURFACE DIAMOND DRILLING
(All minerals except oil and gas)

Canadian Reserves of Selected Mineral Commodities

(Data available in 1986)

J. ZWARTENDYK

Any assessment of future supply of a given mineral commodity from Canadian mines requires information on current working inventories, i.e., on the amounts of ore known to be present in operating mines and on additional known tonnages in deposits that are close to being profitably mineable. The tonnages that - in 1986 - were fairly well delineated and judged to be mineable are reported below as "reserves" (Figure 1). The limits of what is included in reserves are further specified in each case.

		1986
(A)	**Copper**	14 384 000 t[1]
	Nickel	7 047 000 t
	Lead	8 012 000 t
	Zinc	23 747 000 t
	Molybdenum	364 000 t
	Silver	28 801 t
	Gold	1 306 814 kg

The quantities of the metals listed above are contained in ore recoverable from current mines (including those "temporarily" closed) and from deposits that had been committed for production up to January 1, 1986.

These quantities represent proved and probable tonnages; any additional "possible" tonnages are not included.

(B) Iron 1 400 million t

This is the quantity of iron contained in known crude ore in producing mines[2]. Ore in undeveloped deposits is not included.

(C) Asbestos 39.1 million t

This represents the fibre content (on average, about 5.5 per cent) of 704 million t of mineable ore reserves in producing mines.

(D) Potash 14 000 million t (K_2O equivalent), corresponding to 23 000 million t KCl product (standard fertiliser - exported product)

This amount would be recoverable by conventional mining (to a depth of about 1 100 m) from known potash deposits. At least an additional 42 000 million t (K_2O equivalent) would be recoverable from known deposits by solution mining at depths beyond 1 100 m; this would represent 69 000 million t of KCl product.

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[1] Metric tonne (2 204.62 pounds avoirdupois).

[2] Estimate updated to 1986 from "MR 170, A Summary View of Canadian Reserves and Additional Resources of Iron Ore", Energy, Mines and Resources Canada, 1977.

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(E) Uranium

	"Reasonably Assured"	
	Proven (Measured)	Probable (Indicated)
	(t U)	
Recoverable from mineable ore, at uranium prices of:		
$Cdn 100/kg U or less:	41 000	119 000
$100 to $150/kg U:	-	72 000

The tonnages refer to uranium recoverable from mineable ore[3]. Unless otherwise specified, uranium "reserves" in Canada refer to the tonnages mineable at uranium prices in the low range only.

(F) Coal

- **Bituminous**	3 087 million t (of which 2 030 million t could be used for metallurgical purposes)
- **Subbituminous**	918 million t
- **Lignitic**	2 263 million t

These represent tonnages that could be profitably recovered as raw coal, given current technology and economics, from measured (proven) and indicated (probable) coal in deposits that are legally open to mining. For the purpose of making these estimates, it was assumed that coal sales would cover the costs of any required infrastructure not already in place[4].

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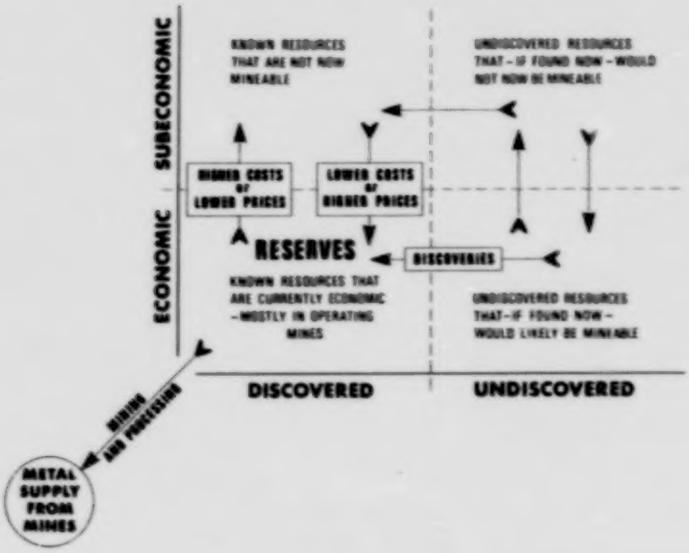
[3] September 1986, Energy, Mines and Resources Canada.

[4] CANMET Report 83-2 OE, "Coal Mining in Canada: 1983", Energy, Mines and Resources Canada, 1984.

THE FLOW FROM RESOURCES TO RESERVES TO MINERAL SUPPLY


SUBECONOMIC
ECONOMIC
KNOWN RESOURCES THAT ARE NOT NOW MINEABLE
UNDISCOVERED RESOURCES THAT - IF FOUND NOW - WOULD NOT NOW BE MINEABLE
HIGHER COSTS OR LOWER PRICES
LOWER COSTS OR HIGHER PRICES
RESERVES
DISCOVERIES
KNOWN RESOURCES THAT ARE CURRENTLY ECONOMIC - MOSTLY IN OPERATING MINES
UNDISCOVERED RESOURCES THAT - IF FOUND NOW - WOULD LIKELY BE MINEABLE
DISCOVERED
UNDISCOVERED
MINING AND PROCESSING
METAL SUPPLY FROM MINES

Aluminum

G. BOKOVAY

Western world aluminum consumption during 1986 was somewhat higher and inventories were significantly lower than 1985 levels, but prices remained relatively depressed. Anticipated labour problems in the United States aluminum industry contributed to some strengthening of aluminum prices during the first half of 1986, but serious supply disruptions did not materialize.

The short-term outlook is for continued price weakness, in view of an anticipated increase in world aluminum production capacity and uncertainty whether the current level of aluminum consumption, particularly in the United States, will be sustained into 1987. In the medium-term, aluminum will face increasing competition from new materials and will also be adversely affected by product downsizing and more efficient manufacturing techniques, but the longer term outlook for the industry remains reasonably optimistic.

The overall cost position of the industry has steadily improved in recent years, in response to persistent market and price weakness. Aluminum producers have continued to implement cost cutting measures and the industry has also benefitted from lower bauxite/alumina prices and more recently from lower energy prices.

The reduction of oil prices has contributed to lower aluminum smelting costs, but it has unfortunately not produced the positive stimulus to economic growth which was anticipated for the major western economies, and consequently for aluminum demand. Moreover, continued low oil prices may ultimately have a negative impact on the demand for lightweight, energy saving materials including aluminum. Lower oil prices will also reduce the cost of plastics which compete with aluminum in various applications.

Continued price weakness has forced the cancellation or postponement of a number of new aluminum smelters in recent years including several in Canada, but new smelter projects in South America were announced in 1986. Assuming these proceed, it is anticipated that a sustained recovery of aluminum prices is still some years away. Moreover, the addition of new low cost capacity will continue to exert pressure on aluminum producers to cut back on smelting operations in certain high cost areas including Europe and the United States.

CANADIAN ALUMINUM INDUSTRY

Three companies produce primary aluminum in Canada: Alcan Smelters and Chemicals Limited, a subsidiary of Alcan Aluminium Limited; Canadian Reynolds Metals Company, Limited, a subsidiary of Reynolds Metals Company of the United States; and Aluminerie de Bécancour Inc. (ABI), a joint venture operation owned by Aluminium Pechiney of France, Alumax Inc. of the United States and the Government of Quebec through Société générale du financement du Québec (SGF).

Alcan has smelters at Jonquière, Grande Baie, Isle Maligne and Shawinigan, Quebec, and at Kitimat, in British Columbia, with a combined capacity of 1 075 000 tpy. Canadian Reynolds operates one smelter at Baie Comeau with a capacity of 272 000 tpy. ABI's new smelter at Bécancour, Quebec has a designed capacity of 230 000 tpy.

At the end of 1986, all Canadian smelters were operating at capacity, with the exception of Alcan's Arvida works in Jonquière, where approximately 88 per cent of the plant's 432 000 t capacity was being utilized, and ABI's facility in Bécancour where start-up of the plant's second 115 000 tpy potline is well under way. This

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smelter was operating at a rate of about 200 000 tpy at year end, with full capacity operations expected by the end of February 1987.

Alcan is the only domestic producer of alumina, the principal raw material for aluminum metal production. The company's refinery, which is located at Jonquière, Quebec, has a capacity of approximately 1.2 million tpy of metallurgical and commercial grade alumina. At present, bauxite requirements for this facility are imported principally from Brazil, Guinea, Guyana and Sierra Leone. Alumina production at Jonquière, which totalled 930 000 t in 1985, is consumed at Alcan's reduction facilities in Quebec, supplemented with alumina from Jamaica. The company's Kitimat plant is supplied with alumina from Australia and Japan.

Alumina for the Canadian Reynolds smelter in Baie Comeau is imported from the United States, West Germany and Jamaica, while the new smelter of Aluminerie de Bécancour is supplied from Australia.

Canadian production of primary aluminum products increased during 1986 to 1.36 million t from 1.28 million t in 1985. Canadian exports of primary smelter products increased to 851 589 t during the first nine months of 1986 from 785 825 t for the same period in 1985. This was primarily due to a substantial increase in exports to the United States. For the nine month period ending September 30, 1986, exports to the United States totalled 650 942 t compared to 513 977 t for the same period in 1985. Meanwhile, shipments to the Asian market decreased from 217 413 t in 1985 to 133 041 t in 1986.

Despite continuing low aluminum prices, Alcan Aluminium Limited reported a consolidated net income of $US 244 million for the year ending December 31, 1986, compared with a loss of $180 million for 1985. Alcan attributed these results to its cost reduction program, an improved product mix and higher average prices, particularly for ingot products.

Alcan intends to increase capital spending in 1987 to $US 450 million from $350 million in 1986, but it has no plans to re-activate its Laterrière smelter project in Quebec, which was put on hold in 1985 due to depressed market conditions. On the other hand, Alcan continued its strategy, first announced in 1985, to restructure its aluminum operations with more emphasis on higher valued, fabricated and semi-fabricated products. In addition, the company intends to pursue investments in new businesses that are technology related. As part of this strategy, Alcan disposed of several operations during 1986. This included the sale of five aluminum extrusion plants in Europe, its holdings in the Netherlands-based Hunter Douglas NV, its subsidiaries in Nigeria and its stake in Hulett Aluminium Ltd. of South Africa. One of the few additions during 1986 was the takeover by Alcan Alluminio SpA Italia of the sheet division of Trafilerie e Laminatoi di Milano. The purchase was scheduled to become effective on January 1, 1987.

Within Canada, Alcan's subsidiary, Aluminum Company of Canada, Limited (Alcan) completed a $US 17 million aluminum cable and wire plant at Shawinigan, Quebec, in August. The plant has a capacity of approximately 15 000 tpy. At the end of 1986, Alcan announced plans to sell its 20.5 per cent interest in Haley Industries Limited, a manufacturer of specialty castings for the aerospace industry, and to redeploy the proceeds to other business opportunities. On January 15, 1987, Alcan announced that it will discontinue the production of aluminum converter foil and aluminum plate at its Kingston, Ontario, fabricating facility. The cutback was expected to affect 355 employees.

Elsewhere in Canada, workers at the aluminum smelter of Canadian Reynolds Metals Company, Limited at Baie Comeau, Quebec, went on strike on March 4 after an impasse developed during contract negotiations. During the strike, which lasted until the end of March, management personnel operated the smelter at approximately 50 per cent of capacity.

The new 230 000 tpy smelter of Aluminerie de Bécancour Inc., was officially opened in September 1986, although full production will not be attained until the end of February 1987. Earlier in the year, Aluminium Pechiney of France, which owns 50.1 per cent of the facility, agreed in principle to sell half its interest to Reynolds Metals Company. According to press reports, Pechiney would continue to act as managing partner of the operation. Pechiney said that this sale was based on a desire to achieve greater flexibility, additional investment in fabricated and semifabricated products being mentioned as possible alternatives. At year end, negotiations were reportedly still under way between Pechiney and Reynolds.

Swiss Aluminium Ltd. (Alusuisse) completed a feasibility study during 1986 for a new 230 000 tpy aluminum smelter in Quebec, but no announcement was made by year end on whether the company will proceed with the project.

WORLD DEVELOPMENTS

Non-socialist world consumption of primary aluminum in 1986 is believed to have been marginally higher than the 12.68 million t recorded in 1985. Preliminary data indicate that primary aluminum production in 1986 was about 12.1 million t compared to 12.26 million t in 1985.

Despite the continuing reduction of smelter capacity in the United States and Japan, overall western world aluminum capacity increased by approximately 200 000 t during 1986 due to the start-up of new facilities and technical improvements to existing smelters.

According to a press report based on a study by Anthony Bird and Associates, the average cost of production, including capital charges, fell from 63 cents per pound (U.S.) in 1985 to 62 cents in 1986. Excluding capital charges the average operating cost was 46 cents per pound compared to 48 cents in 1985. Average 1986 operating costs were 38 cents (U.S.), in Australia, 39 cents in Canàda, 42 cents in Brasil, 50 cents in France and 52 cents in the United States. The most significant change from 1985 was the dramatic decline of smelting costs in the United States. A similar report published a year earlier put average United States smelting costs at 57 cents per pound.

Aside from the benefit of concessions gained during the recent round of labour negotiations, the principal reason for the improvement of United States aluminum smelting costs has been the significant reduction of electric power costs, particularly in the Pacific Northwest. In August, the Bonneville Power Administration introduced a new variable power rate tied to the price of aluminum ingot. At a U.S. transaction price of 53 cents per pound or less, electric power rates under this plan are set at 15 mills per kwh. Bonneville Power's standard industrial rate is 22.8 mills per kwh.

With the expiration of labour agreements affecting a large share of United States aluminum smelting capacity, contract negotiations in that country attracted significant attention during 1986. Given the uncompromising attitude of unions to unreciprocated concessions and the uncompetitive nature of the U.S. aluminum industry in general, significant labour difficulties seemed inevitable. Not unexpectedly, strikes which began with the Aluminum Company of America (Alcoa) on June 1 spread during the summer to include Alcan Aluminium Corporation, Ormet Corp., Alumax Inc., Commonwealth Aluminum Corp. and Noranda Aluminum Inc.

In the event, although certain contract disputes dragged on until late in the year, the overall effect on the U.S. industry was minimal. Some output was lost but management personel were used to keep most plants operating at reduced capacity. Furthermore, labour problems at Alcoa, the largest U.S. producer, were settled at the beginning of July.

Despite the hard-line stance of the unions, the new labour agreements in general provide for significant concessions by the aluminum workers. The new three-year agreements between the United Steel Workers and Alcoa and Reynolds involve cuts of 95 cents in total worker compensation, which stood at $24 per hour under the terms of the old labour pact. Meanwhile, workers at Commonwealth Aluminum's Goldendale, Washington smelter accepted a $1.25 per hour cut in wages and a 48 cent per hour cut in a cost of living adjustment. Employees at Noranda Aluminum's smelter in Missouri accepted a 14 per cent reduction in wages and benefits and those at Alcan Aluminium Corporation's smelter at Sebree, Kentucky agreed to a wage and benefit cut amounting to $4.60 per hour.

In line with an announcement made by Alcoa in 1985, the company implemented permanent production cutbacks during 1986 amounting to 350 000 tpy of smelting capacity. This included the permanent closure of its Anderson County, Texas and Vancouver, Washington smelters as well as the reduction of some capacity at Rockdale, Texas and Massena, New York. The Vancouver, Washington smelter, which was closed in early-June, did not reopen during the rest of 1986 but it could reopen in 1987 if negotiations for the sale of the facility to Vanalco Inc., a subsidiary of Bay Resource Corp., can be successfuly concluded.

In August, Consolidated Aluminium Corp., the U.S. subsidiary of Alusuisse, announced that it was closing its New

Johnsonville, Tennessee smelter at the end of 1986. In September, Ormet Corp., which was owned 66 per cent by Consolidated and 34 per cent by Revere Copper & Brass Incorporated, was sold to the investor group, Ohio River Assoc. Inc. The new operators will continue to supply aluminum to the original owners for the next few years but the smelter will eventually become a toll conversion facility for Clarendon Ltd., Marc Rich's U.S. associate. During 1986, Clarendon also signed tolling agreements with Alumax Inc. for output from that company's Mount Holly, South Carolina smelter and also for aluminum from the smelter at Dalles, Oregon, formerly operated by Martin Marietta Aluminium Inc. The smelter at Dalles, which has been idle since December 1984, was transferred to Northwest Aluminum Inc. in September under a lease-purchase agreement. The startup of one of the plant's two 40 500 tpy potlines was completed in early-December but there have been no announcements regarding the second potline.

In late-November, Comalco Limited of Australia announced that its Goldendale, Washington smelter, operated by Commonwealth Aluminum Corp., would be closed at the end of 1986. Although, the closure was delayed to permit evaluation of several potential offers for the plant, it was finally closed in February 1987.

Meanwhile, prospects for continued operation of the Columbia Falls, Montana smelter, which was sold by ARCO Aluminum Co. to Montana Aluminum Investors Corp. in 1985, improved during 1986 with the signing of tolling agreements with the Swiss-based trading arm of Norsk Hydro AS and also with The Broken Hill Proprietary Company Limited (B.H.P.) of Australia.

In November 1986, Mitsui and Co. USA Inc. and Nippon Steel USA Inc. agreed to relinquish their 50 per cent interest in Alumax Inc. to AMAX Inc. of the United States, the other principal shareholder of the company. The change in ownership, which was made at the request of AMAX, was in response to changes in the United States federal income tax legislation which become effective in 1988.

After several years of rapid growth, the Brasilian aluminum industry encountered several obstacles during 1986 which threaten to slow the pace of future development. Beginning in March, electric power rate increases, threatened power shortages and a policy debate on energy subsidization for the aluminum industry, have dampened expectations for significant future expansion. In addition, at the end of 1986, the Japanese consortium Nippon Amazon Aluminum Co. (NAAC) announced that it would not proceed with further investment in the 800 000 tpy (Alunorte) alumina refinery in the northern part of the country. However, the project's Brasilian partner, Companhia Vale do Rio Doce (CVRD), has stated that it intends to look for new equity investment. Alunorte was originally scheduled for completion in 1988.

Both NAAC and CVRD are also involved in the Albras aluminum smelter project. The first phase of this development, representing 160 000 tpy capacity, was scheduled for completion in January 1987. While Nippon Amazon has stated that it remains committed to the second phase of the Albras project, financing arrangements have still to be negotiated.

Elsewhere in Brasil, the second potline of the new 245 000 tpy Alumar aluminum smelter project was commissioned during 1986. Alcoa and Billiton Metais SA, a subsidiary of Shell Brasil SA, the joint owners of the facility, were reported to be considering the addition of a third potline, although no firm decision has yet been made.

In Venezuela, several new aluminum projects were announced in 1986, which are expected to almost double that country's aluminum output by 1990. Aluminio del Caroni SA (Alcasa), one of two Venezuelan primary metal producers, is proceeding with an 84 000 tpy expansion to its existing 120 000 tpy smelter at Puerto Ordaz. The project is expected to be completed in mid-1988. The company is also considering the construction of a new 180 000 tpy smelter for completion in 1990. Also during 1986, Alcasa announced plans for a major expansion of existing rolling capacity as well as a new coke calcination facility.

As part of a strategy to secure long-term markets for its aluminum output, Alcasa entered into an agreement with Reynolds Metals whereby the former acquired a 50 per cent interest in Reynolds Aluminium Europe S.A. (Aleurope). It is expected that Alcasa will supply 12 000 tpy of aluminum foil and 16 000 tpy of billets to the European fabricator.

The other Venezuelan producer, Industria Venezolana de Aluminio SCA (Venalum), is proceeding with a 143 000 tpy expansion of its smelting capacity which will increase output to 423 000 tpy. During 1986, it was also reported that the Venezuelan wire producer, Suramericana de Aleaciones Laminados (SURAL), was planning to build a 115 000 tpy smelter in a joint venture with Austria Metall A.G. It is expected that this plant will come on-stream in 1989.

Although Venezuela currently imports its bauxite requirements, this will change once the new $462 million Bauxiven mine at Los Pijiguaos in Bolivar state comes on-stream in 1987. The mine is to be completed in 1988 at which time annual output will reach 2.75 million t. To cope with increased aluminum output, the state-owned alumina producer Interamericana de Alumina CA (Interalumina) is increasing its capacity from 1.1 million tpy to 1.5 million tpy and eventually to 2.5 million tpy.

Elsewhere in South America, the Surinam Aluminum Company (Suralco), a subsidiary of Alcoa, suspended mining operations at its Moengo bauxite mine in November 1986 following a guerilla attack. While the company began to import bauxite in January 1987 to feed its Paranam alumina refinery, the destruction of electrical transmission lines by the guerillas at the end of the month forced Suralco to suspend refining and smelting operations.

In Jamaica, the government and Kaiser Aluminum & Chemical Corporation entered into discussions on reopening the Alpart alumina refinery. That facility, which is jointly owned by Kaiser and Reynolds Metals, was closed in 1985 due to depressed market conditions. Meanwhile, the Jamaican government continued to operate the Clarendon alumina refinery during 1986. The plant, which is owned by Alcoa, was reopened by the government in July 1985 after Alcoa closed the facility in February of that year.

In Australia, the first 150 000 tpy potline of the new Portland aluminum smelter was scheduled to be fully operational by January 1987. The smelter is owned by Alcoa of Australia Ltd., the Victoria government body Aluvic and the China International Trust Investment Corp. During 1986, the Western Australia government stated that it had no plans to revive the so-called Western Australia aluminum smelter project, which was abandoned in 1985.

After lengthy negotiations with the United States and the threat of retaliatory trade action by that country, Japan agreed to reduce its tariffs on aluminum imports from 9 to 5 per cent on aluminum ingot, and from 9.2 to 6.1 per cent on aluminum plate, sheet and strip. Additional reductions will be implemented, on January 1, 1988, lowering tariffs to 1 and 3 per cent, respectively.

With high operating costs and the dramatic appreciation of the Yen, the Japanese primary aluminum industry virtually disappeared in 1986. Following the cessation of smelting operatings by Showa Light Metal Company Ltd. in February, Sumitomo Aluminium Smelting Co., Ltd. closed its Toyama plant at the end of October. In late-1986, Mitsubishi Chemical Industries Ltd. announced that it would close its 51 000 tpy Sakaide smelter, which is operated by its subsidiary Ryoka Light Metals Company. Meanwhile, Mitsui Aluminium Company Ltd. confirmed in December that it would cease production at its 125 000 tpy Miike aluminum smelter. Both closures are scheduled to take effect in March 1987. Nippon Light Metal Co. Ltd.'s 64 000 tpy Kambara smelter will be the only primary reduction facility left in Japan. However, with drought conditions affecting the company's hydro-electric generating capacity, the company was scheduled to reduce output to a rate of 35 000 tpy beginning in December. Japanese smelting capacity in the late-1970s was approximately 1.6 million tpy.

In addition to cutbacks in Japanese smelting capacity, Nippon Light Metal announced in July that it was closing its 360 000 tpy Tomakomai alumina plant at the end of the year.

In the People's Republic of China, the 1986-90 five year plan includes six new aluminum smelter projects and expansions at several existing facilities. Assuming all projects proceed, primary aluminum smelting capacity will increase from 400 000 tpy to over 800 000 tpy by 1990 and eventually to 1 200 000 tpy. Specific projects include the 200 000 tpy Weinan smelter in Shanxi province, a 100 000 tpy plant at Pingguo in the Guangxi Zhuang autonomous region and another 100 000 tpy facility at Xining Shi in Quinghai province. During 1986, it was reported that Showa Light Metal Company Ltd. of Japan would ship its mothballed Chiba smelter to China beginning in March 1986. The plant will be reassembled at Baijin, near Lanchous in the central northwest part of the country.

In February 1986, Aluminium Pechiney signed a contract to provide technical assistance for part of a new 660 000 tpy alumina plant at Hejin in Shanxi province. This plant is scheduled for completion in 1990.

In July, it was announced that Alcan Nikkei China Ltd., owned by Alcan and the Alcan affiliate Nippon Light Metal Co., had entered into a joint venture with China National Nonferrous Industry Shenzhen Associated Corporation to establish an integrated aluminum extrusion and manufacturing plant in the Shenzhen special economic zone. Cost of the plant is estimated at $US 20 million.

In India, Hindustan Aluminium Corp. Ltd. (Hindalco) announced during 1986 that it was proceeding with a smelter modernization project in collaboration with Kaiser Aluminum & Chemical Corporation. The program will increase capacity by 30 000 tpy. Hindalco's new alumina plant is to be commissioned in mid-1986.

Also in India, National Aluminium Co. Ltd. (Nalco) was scheduled to complete the first phase of its new 800 000 tpy alumina refinery in Orissa State in September 1986 with the first potline of the new 218 000 tpy aluminum smelter expected to begin production at the end of the year. The project also includes a 2.4 million tpy bauxite mine.

In Bahrain, the government approved modernization plans for the country's Alba smelter whereby capacity will be increased to 200 000 tpy by 1989. Also during 1986, a new 40 000 tpy rolling mill was inaugurated. The mill, which is located near the Alba smelter, was financed by Bahrain, Saudi Arabia, Kuwait, Iraq, Oman and Qatar. It was reported that a new 240 000 tpy smelter will be built in the United Arab Emirates using Alcoa technology. The People's Republic of China, Southwire Co. of the United States and Japan's Furakawa Co. Ltd. have been mentioned as possible buyers for the output from this facility. Construction was scheduled to begin in January 1987. It was also reported during 1986 that Saudi Arabia is reconsidering plans for a new 200 000 tpy smelter in that country. Similar plans were apparently shelved in 1985.

In Norway, a merger between Norsk Hydro AS and Ardal Og Sunndal Verk A.S. ASV of Norway was completed in September 1986. Production at Mosal Aluminium Elkem a/s & Co. Mosjoen smelter was expected to increase from 90 000 tpy to 115 000 tpy by 1989 as a result of a modernization program.

As a result of mounting losses, Alusuisse announced during 1986 its intention to close some of its European smelting capacity and to concentrate on more profitable downstream operations. To date, the company has announced that it will close 50 per cent of the capacity at its 24 000 tpy smelter at Chippis, Switzerland as well as a 24 000 tpy smelter at Reinfelden in West Germany. In addition, Alusuisse sold a 24.8 per cent interest in the Norwegian producer, Sor-Norge Aluminium A/S, to Norsk Hydro and was considering the sale of its Nigerian holdings and 50 per cent interest in the 60 000 tpy smelter at Sava Aluminio Veneto S.p.A. in Italy.

Hoogovens Groep BV, a subsidiary of Koninklijke Nederlandsche Hoogovens en Staalfabrieken NV, was reported early in 1987 to be negotiating with Kaiser Aluminum & Chemical Corporation for the purchase of Kaiser Aluminium Europe Incorporated. If concluded, the deal would include an aluminum smelter at Voerde in West Germany as well as fabricating facilities in Germany, Belgium and Switzerland.

Also in West Germany, Alcan announced plans to reduce output at its 44 000 tpy Ludwigshafen smelter by 50 per cent. Aluminium Norf GmbH (Alunorf) which is jointly owned by Alcan and Vereinigte Aluminium-Werke AG (VAW), expects to commission a new 170 000 tpy cold mill in West Germany by April 1987. The mill will have a capability to produce a product up to 2.12 meters in width.

In France, Aluminium Pechiney will phase out its 115 000 tpy Noguères and its 25 000 tpy Riouperoux smelters over a five year period beginning in 1987. Pechiney's new potline at St. Jean de Maurienne smelter was fully operational by the end of October. The expansion and modernization of the plant increased capacity by 40 000 tpy to 120 000 tpy. Pechiney also intends to rationalize its French raw materials operations with the closure of its 360 000 tpy alumina refinery at La Barrase and cessation of bauxite mining in Peygros in 1987.

After years of negotiation, it is expected that the new 600 000 tpy alumina refinery near Delphi in Greece will finally proceed. Under an agreement between the U.S.S.R. and Greece, the former will take an equity position in the $US 550 million refinery and will take its total output.

USES

Aluminum's low density, high strength and corrosion resistance make it suitable for use in alloyed and unalloyed forms in a wide variety of products. In the building and construction industry, major uses for aluminum include residential siding; window and door frames; screens; awnings and canopes. In the transportation sector, aluminum is widely used in the manufacture of buses, trucks, trailers and semi-trailers and is the principal metal in aircraft. In this regard, new aluminum-lithium alloys promise to deliver significant weight savings over traditional aircraft alloys. However, the high price of such alloys, which are currently as much as three times the price of conventional aircraft alloys, prohibits their widespread application at this time. Aluminum is also being increasingly used in passenger cars as manufacturers move to reduce the weight of their vehicles.

General Motors decided to curtail development of its aluminum-intensive series 3200 high-performance V-6 engine, but Chrysler is using aluminum to a large extent in the new V-6 gasoline engines for its compact vans. However, General Motors will produce a new one-piece aluminum driveshaft for its 1988 light truck line. During 1986, Alcoa announced that it is developing an aluminum space frame for automobiles which it hopes could be in commercial production in the 1990s. The frame would weigh approximately 400 pounds compared to 660 pounds if made from steel. The new frame would reduce the number of separate body parts to about 75 from approximately 400 in unitized bodies.

In the electrical field, aluminum extensively replaced copper in wiring and power transmission in the 1960s but, while it has maintained the market for power transmission applications, local restrictions and consumer resistance have substantially lessened the demand for aluminum in electrical wiring. Aluminum has however gained acceptance in various communications and computer applications.

During 1986, Alcoa announced the development of a new coating process using electrophoresis that it hopes will enable aluminum to penetrate into the large food can industry. Until now, only shallow aluminum food cans have been commercially viable because of limitations in coating technology. As a first stage in market development, Alcoa entered into a joint venture with Central States Can Co. to manufacture and promote the commercial use of aluminum food cans. Central Can will build a new aluminum can plant using Alcoa technology that should be completed in 1988. Output per line will be about 900 cans per minute compared to 400 to 500 for a typical steel food can production circuit. The potential market for aluminum food cans is estimated by Aloca at 1 billion pounds annually.

Another application for aluminum is the new aluminum air cell which produces electricity from the oxidation of aluminum metal. While this battery is still in development, it promises to deliver more energy than conventional batteries.

PRICES AND STOCKS

Aluminum prices on the London Metal Exchange rose in late-1985 and during the first half of 1986, but there was no discernable trend thereafter. Nevertheless, there was a significant improvement over 1985 with the average cash settlement price reaching 52 cents (U.S.) per pound compared to 47.9 cents in the previous year.

With the threat of a prolonged strike in the United States, LME prices did strengthen through the first half of 1986. However, since U.S. labour problems had only a minimal effect on aluminum supplies and also their timing corresponded with the normal summer slowdown of consumption, prices were significantly lower in July and August. Prices rebounded in September, reflecting considerable tightness in the aluminum market, but then weakened through the final quarter of the year.

In an effort to increase the attractiveness of the London Metal Exchange for consumers and producers, that institution established a special subcommittee in September to examine among other things, the establishment of a new U.S. dollar contract for 99.7 per cent metal, the most commonly traded form of aluminum. Additional delivery points outside Europe will also be considered. The current LME contract for 99.5 per cent material has been criticized for some time as being unrepresentative in terms of metal quality, volume of aluminum traded and the medium of exchange. In particular, the lack of adequate stocks in relation to increasing options business, has been blamed for the recent volatility of aluminum spot prices.

The International Primary Aluminum Institute reported that total inventories of aluminum (including scrap, primary and secondary ingot, metal in process and finished mill products) in December 1986 stood at 3.589 million t compared to 3.966 million t in December 1985. Meanwhile, primary metal stocks also declined over the same period from 2.188 million t to 1.884 million t.

During 1986, spot alumina prices strengthened significantly with transactions in the second half of the year reported in the $US 130 to $140 per t range. During 1985, alumina spot prices were reported to be below $100 per t.

At the end of November, the International Bauxite Association (IBA) announced a new pricing system for bauxite and alumina to be based on an IBA composite reference price for aluminum ingot. This reference will be based on the LME, transaction prices in various markets, list prices and regional market shares. According to the IBA, the minimum recommended CIF price for base grade metallurgical bauxite will be 2.5 to 3.5 per cent of new reference price while the CIF price for alumina will be between 14 and 18 per cent of the same reference price.

OUTLOOK

Aside from a possible market breakthrough in food cans, there are few if any totally new frontiers that offer potential for a dramatic increase in aluminum consumption. Nevertheless, it is expected that increased consumption in traditional markets will provide aluminum with a better than average growth rate in the metals industry. In this regard, aluminum demand is forecast to increase at an average annual rate of between 1.5 and 2.0 per cent in the next decade.

Despite the introduction in recent years of a variety of substitutes, recent breakthroughs in the development of advanced aluminum based alloys/materials and more efficient fabricating techniques, will allow the aluminum industry to hold its own in an intensely competitive environment.

The most promising area for future aluminum growth is the transportation goods sector. While the list of possible new or expanded applications for aluminum in this area is extensive, the most important are expected to be railway cars, dump trucks and automobiles. For example, it is suggested that the unit content of aluminum in 1987 model North American automobiles will increase to between 145 and 150 pounds from 139 pounds in 1986.

The packaging sector still offers some growth potential in the United States, particularly for aluminum beverage cans, but is constrained by a higher rate of recycling and thinner walled products. The Aluminium Association Incorporated of the United States has reported that a record 33.1 billion aluminum cans representing 567 000 t were recycled during 1985.

Given the expected increase in production and limited real growth in consumption in the short-term, it is expected that the average price of aluminum will not exceed 60.0 cents (1986 constant U.S. cents) per pound during 1987, assuming no further deterioration in the value of the U.S. dollar. Despite the relatively optimistic outlook for consumption in the longer term, the addition of significant new, low-cost capacity will continue to exert downward pressure on aluminum prices. Therefore, it is expected that aluminum will trade in the range of 52.50 to 57.50 cents (1986 constant cents) in the next decade.

The geographical distribution of the primary aluminum industry has undergone profound changes in the past decade, as evidenced by the near disappearance of Japanese aluminum smelters and the significant cutback of capacity in the United States, and significant restructuring will continue. Despite the appreciation of certain European currencies and relatively high power costs in that region, it is expected that the majority of smelter closures in the next few years will continue to be in the United States.

With continuing low metal prices and uncertainty about sustained recovery in the near future, it is unlikely that new aluminum smelter capacity will be built in Canada for some time. A possible exception is Alcan's proposed smelter at Laterrière, Quebec, where established infrastructure and the need to replace inefficient older capacity may provide sufficient reason to proceed in the near future. Nevertheless, the Canadian industry is one of the lowest cost producers and Canada will continue to be a major player in the international aluminum industry.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
CANADA					
32910-1	Bauxite	free	free	free	free
35301-1	Aluminum pigs, ingots, blocks, notch bars, slabs, billets, blooms and wire bars, per pound	free	.1¢	5¢	free
35302-1	Aluminum bars, rods, plates, sheets, strips, circles, squares, discs and rectangles	free	2.1	9	free
35303-1	Aluminum channels, beams, tees and other rolled, drawn or extruded sections and shapes	free	8.6	30	free
35305-1	Aluminum pipes and tubes	free	8.6	30	free
92820-1	Aluminum oxide and hydroxide; artificial corundum (this tariff includes alumina)	free	free	free	free

MFN Reductions under GATT (effective January 1 of year given)		1986	1987
35301-1		.1¢	free
35302-1		2.1	2.1
35303-1		8.6	8.0
35305-1		8.6	8.0
92820-1			
UNITED STATES (MFN)			
417.12	Aluminum compounds: hydroxide and oxide (alumina)	Remains free	
601.06	Bauxite	Remains free	
618.01	Unwrought aluminum in coils, uniform cross section not greater than 0.375 inch, per pound	2.7	2.6
618.02	Other unwrought aluminum, excluding alloys, per pound	0.1¢	free
618.04	Aluminum silicon, per pound	2.2	2.1
618.06	Other aluminum alloys, per pound	0.1¢	free
618.10	Aluminum waste and scrap, per pound	2.0	2.0

Sources: Customs Tariff 1986, Revenue Canada, Customs & Excise; Tariff Schedules of the United States Annotated (1986), USITC Publication 1775; U.S. Federal Register Vol. 44, No. 241.

TABLE 1. CANADA, ALUMINUM PRODUCTION AND TRADE, 1984-86

	1984		1985		1986P	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Production	1 221 985	..	1 282 316	..	1 355 161	..
Imports					(Jan.-Sept.)	
Bauxite ore						
Brazil	1 511 220	59,826	1 401 962	58,304	632 917	23,974
Guyana	586 928	20,358	398 428	18,793	225 534	11,457
Guinea	154 105	9,172	105 398	9,438	196 831	9,881
United States	40 342	6,936	43 824	7,193	39 398	7,372
Sierra Leone	0	0	0	0	124 815	4,019
People's Republic of China	56 531	5,610	51 497	5,326	16 600	1,919
Australia	74 742	10,001	51 724	6,662	8 501	1,026
Surinam	13 196	1,129	11 990	626	14 368	1,011
Greece	14 477	527	9 183	473	10 004	561
French Guyana	0	0	200	44	0	0
Total	2 451 541	113,558	2 074 206	106,859	1 268 968	61,221
Alumina						
Jamaica	549 317	121,313	651 687	137,333	409 390	76,205
Australia	308 388	71,167	239 107	44 472	370 450	73,665
Japan	276 696	63,966	286 501	58,458	220 249	46,363
United States	56 288	20,814	71 990	21,456	175 462	41,138
West Germany	132 408	40,986	180 724	43,000	25 029	5,977
Venezuela	26 057	4,671	59 925	6,156	33 005	4,763
France	0	0	220	155	167	130
Netherlands	0	0	0	0	36	29
United Kingdom	8	5	2	1	8	4
U.S. Virgin Islands	0	0	25 038	6, 329	0	0
People's Republic of China	51	21	0	0	0	0
Ireland	0	0	28 813	5,309	0	0
Total	1 349 213	322,942	1 544 077	322,670	1 233 796	248,275
Aluminum and aluminum alloy scrap	61 781	63,345	53 376	47,489	55 316	48,576
Aluminum paste and aluminum powder	1 846	7,390	1 318	6,481	1 231	5,906
Pigs, ingots, shot, slabs, billets, blooms and extruded wire bars	44 566	86,996	59 762	109,886	50 917	95,706
Castings	989	13,142	1 294	16,210	1 040	10,568
Forgings	806	13,831	913	17,104	450	11,148
Bars and rods, nes	6 447	19,906	7 015	20,761	5 886	17,166
Plates	9 613	33,829	9 556	32,863	9 835	33,689
Sheet and strip up to .025 inch thick	17 973	59,768	24 729	76,325	25 913	73,547
Sheet and strip over .025 inch up to .051 inch thick	14 071	50,789	15 612	54,835	11 848	42,530
Sheet and strip over .051 inch up to .125 inch thick	90 327	227,671	73 313	153,347	41 889	100,681
Sheet over .125 inch thick	38 058	103,207	33 438	77,179	26 129	67,806
Foil or leaf	806	3,414	999	3,736	1 405	4,946
Converted aluminum foil	..	15,122	..	15,968	..	11,019
Structural shapes	2 914	12,658	4 169	18,666	4 126	17,602
Pipe and tubing	1 559	7,575	2 611	11,362	2 732	11,515
Wire and cable, not insulated	1 576	5,606	1 765	5,785	2 030	6,334
Aluminum and aluminum alloy fabricated materials, nes	..	68,847	..	89,956	..	78,283
Exports						
Pigs, ingots, shot slabs, etc.						
United States	611 940	1,167,382	683 306	1,088,416	650 944	1,183,136
Japan	110 898	181,967	142 210	199,099	70 808	103,860
Turkey	0	0	36 020	55,995	19 638	31,652
Korea, South	941	1,433	8 028	11,712	15 629	25,599
Hong Kong	9 584	16,501	21 289	33,423	14 210	24,623
Sweden	5	36	6 308	9,076	12 998	21,461
Taiwan	4 398	7,061	22 991	35,978	12 338	20,701
People's Republic of China	42 993	70,519	7 796	98,526	9 731	14,926
Other	52 872	104,351	62 981	104,689	45 300	78,920
Total	833 631	1,549,249	1 050 789	1,636,915	851 596	1,504,878
Castings and forgings						
United States	8 054	65,054	8 820	74,775	8 578	71,397
Total	8 587	76,182	9 009	83,051	8 712	76,891
Bars, rods, plates, sheets and circles						
United States	67 251	194,439	43 996	115,414	32 674	87,887
Total	72 214	208,692	55 070	138,078	38 556	99,866
Foil or Leaf						
United States	1 311	5,174	1 610	5,062	1 525	4,779
Total	1 339	5,289	1 642	5,214	1 610	5,129
Fabricated materials, nes						
United States	11 106	39,990	9 791	36,770	7 317	28,013
Total	18 056	62,380	12 121	44,057	8 598	33,165
Ores and concentrates						
United States	46 505	22,019	48 643	22,897	31 473	15,014
Total	50 644	24,760	52 577	25,568	34 299	16,972
Scrap						
United States	97 820	129,565	97 688	111,770	73 432	95,426
Total	105 170	138,561	113 277	129,821	89 942	114,688

Sources: Statistics Canada; Energy, Mines and Resources Canada.
P Preliminary; - Nil; .. Not available; nes Not elsewhere specified.

TABLE 2. CANADA, CONSUMPTION OF ALUMINUM METAL AT FIRST PROCESSING STAGE, 1983-85

	1983	1984	1985^{P}
		(tonnes)	
Castings			
Sand	964	1 639	1 640
Permanent mould	12 490	12 832	16 180
Die and other	27 511	33 041	31 368
Total	40 965	47 512	49 188
Wrought products			
Extrusions, including tubing	86 162	93 730	92 111
Sheet, plate, coil and foil	133 271	155 242	130 522
Other wrought products (including rod, forgings and slugs)	62 786	72 712	57 286
Total	282 219	321 684	279 919
Other uses			
Destructive uses (deoxidizer), non-aluminum base alloys, powder and paste	9 205^{r}	10 053	16 926
Total consumed	332 388^{r}	379 249	346 033
Secondary aluminum[1]	67 992^{r}	63 401	78 047

	Metal entering plant			On hand December 31		
	1983	1984	1985	1983	1984	1985
Primary aluminum ingot and alloys	324 933	395 501	310 230	40 082^{r}	28 675	30 131
Secondary aluminum	44 166	53 634	55 372	3 947	5 868	4 495
Scrap originating outside plant	79 493	76 592	89 747	2 819	4 759	5 904
Total	448 592	525 727	455 349	46 848^{r}	39 302	40 530
Aluminum shipments[2]				43 265	90 623	30 041

[1] Aluminum metal used in the production of secondary aluminum is not included in consumption totals. [2] Aluminum metal shipped without change. Does not refer to shipments of goods of own manufacture.
Note: Revisions reflect changes to company specific data.
^{P} Preliminary; ^{r} Revised.

TABLE 3. CANADA, ALUMINUM SMELTER CAPACITY

(as of December 31, 1986)

	Annual tonnes
Aluminum Company of Canada, Limited	
Quebec	
Grande Baie	171 000
Jonquière	432 000
Isle-Maligne	73 000
Shawinigan	84 000
Beauharnois	47 000
British Columbia	
Kitimat	268 000
Total Alcan capacity	1 075 000
Canadian Reynolds Metals Company, Limited	
Quebec	
Baie Comeau	272 000
Aluminerie de Bécancour Inc.	
Quebec	
Bécancour	200 000
Total Canadian capacity	1 547 000

Source: Compiled from company reports by Energy, Mines and Resources Canada.

TABLE 4. AVERAGE 1986 PRICES

Month	LME Cash	U.S. Market
	(¢ U.S./pound)	
January	50.77	55.25
February	50.56	56.82
March	52.98	61.57
April	52.82	59.35
May	52.81	57.77
June	53.66	56.74
July	50.94	54.13
August	51.22	54.49
September	54.70	55.41
October	52.71	53.57
November	51.34	52.50
December	51.40	52.56
1986 Average	52.18	55.87
1985 Average	47.85	48.81

Source: Metals Week.

TABLE 5. ESTIMATED NON-COMMUNIST WORLD PRODUCTION OF ALUMINA

	1982	1983	1984	1985	1st Qtr 1986	2nd Qtr 1986	3rd Qtr 1986
	(million tonnes)						
Europe[1]	4.46	4.35	5.24	4.87	1.17	1.23	1.33
Africa	0.58	0.56	0.55	0.58	0.14	0.14	0.14
Asia	1.81	1.89	2.12	2.00	0.45	0.42	0.43
North America	5.27	5.07	5.75	4.56	0.99	0.98	1.00
Latin America	3.48	4.17	4.60	4.73	1.20	1.33	1.43
Oceania	6.63	7.31	8.80	8.80	2.17	2.33	2.45
Total	22.23	23.35	27.06	25.54	6.12	6.43	6.79
of which nonmetallic uses	1.97	2.06	2.31	2.34	0.60	0.63	0.57

Source: International Primary Aluminum Institute.

[1] Excludes Yugoslavia.

TABLE 6. WORLD MINE PRODUCTION OF BAUXITE

	1983	1984	1985
		(000 tonnes)	
EUROPE			
France	1 995.3	1 529.5	1 529.6
Greece	2 455.2	2 293.8	2 367.2
Italy	13.1	-	-
Spain	5.2	7.3	7.0
Yugoslavia	3 500.0	3 347.0	3 250.0
Total	7 568.8	7 177.6	7 153.8
AFRICA			
Ghana	70.2	44.2	124.5
Guinea	12 986.0	14 738.0	14 329.0
Sierra Leone	785.2	1 042.0	1 144.7
Zimbabwe	23.1	22.7	28.9
Total	13 864.5	15 846.9	15 627.1
ASIA			
India	1 976.1	2 072.2	2 121.0
Indonesia	968.4	1 003.1	830.5
Malaysia	501.8	680.4	491.9
Turkey	306.4	131.6	213.8
Total	3 752.7	3 887.3	3 657.2
AMERICA			
United States	679.0	856.0	674.0
Brazil	5 238.7	6 433.1	5 846.0
Dominican Republic	-	-	-
Guyana	1 087.3	2 484.7	2 296.4
Haiti	-	-	-
Jamaica	7 681.9	8 734.9	6 239.3
Surinam	2 793.0	3 374.9	3 738.3
Total	17 479.9	21 883.6	18 704.0
AUSTRALASIA			
Australia	24 372.0	32 182.0	31 178.0
TOTAL	**67 037.9**	**80 977.4**	**76 320.1**
Monthly Average	5 586.5	6 748.1	6 360.0
OTHER COUNTRIES			
China	1 900.0	2 000.0	2 100.0
Hungary	2 917.0	2 994.0	2 691.4
Romania	420.0	460.0	500.0
U.S.S.R.	6 300.0	6 200.0	6 400.0
Total	11 537.0	11 654.0	11 691.4
WORLD TOTAL	**78 574.9**	**92 631.4**	**88 011.5**

Source: World Bureau of Metal Statistics.
- Nil.

TABLE 7. WORLD PRODUCTION OF ALUMINUM

	1983	1984	1985
		(000 tonnes)	
EUROPE			
France	360.8	341.5	293.2
Germany, F.R.	743.4	777.2	745.4
Italy	195.7	230.2	226.1
Netherlands	236.3	247.3	243.9
Norway	710.6	760.8	724.1
Spain	357.5	380.8	370.1
United Kingdom	252.5	287.9	275.4
Yugoslavia	258.2	267.5	271.1
Other	465.6	476.5	450.6
Total	3 580.6	3 769.7	3 597.9
AFRICA			
Total	421.4	413.0	473.2
ASIA			
Bahrain	171.7	177.3	174.8
India	204.8	267.9	266.5
Indonesia	114.8	199.0	216.8
Japan	255.9	286.7	226.5
U.A.E.	151.2	155.4	153.2
Other	82.2	98.2	114.6
Total	980.6	1 184.5	1 152.4
AMERICA			
Canada	1 091.2	1 222.0	1 278.8
United States	3 353.2	4 099.0	3 499.7
Brazil	400.7	455.0	509.4
Venezuela	335.2	386.0	403.1
Other	205.0	204.8	211.4
Total	5 385.3	6 366.8	5 942.4
AUSTRALASIA			
Australia	475.1	754.8	851.7
New Zealand	220.1	242.9	243.5
Total	695.2	997.7	1 095.2
TOTAL	**11 063.1**	**12 731.7**	**12 261.1**
Monthly Average	921.9	1 061.0	1 021.8
SOCIALIST COUNTRIES			
Romania	223.3	244.0	220.0
U.S.S.R.	2 400.0	2 300.0	2 300.0
Other European	209.9	209.7	212.6
China and Other Asia	410.0	435.0	435.0
Total	3 243.2	3 188.7	3 167.6
WORLD TOTAL	**14 306.3**	**15 920.4**	**15 428.7**

Source: World Bureau of Metal Statistics.

TABLE 8. WORLD CONSUMPTION OF ALUMINUM

	1983	1984	1985
		(000 tonnes)	
EUROPE			
Belgium	272.0	300.8	284.8
France	613.4	579.3	586.1
Germany, F.R.	1 085.0	1 151.6	1 158.0
Italy	430.0	448.0	470.0
Spain	217.4	191.4	195.2
United Kingdom	323.4	369.5	350.4
Yugoslavia	152.0	159.6	168.2
Other Europe	699.7	736.2	746.6
Total	3 792.9	3 936.4	3 959.3
AFRICA			
Total	177.6	196.5	202.2
ASIA			
India	218.5	310.0	297.6
Japan	1 800.7	1 743.9	1 815.6
Other Asia	730.9	580.6	735.3
Total	2 750.1	2 634.5	2 848.5
AMERICA			
Canada	248.0	311.0	245.0
United States	4 218.0	4 572.8	4 400.0
Brazil	270.6	294.7	366.7
Other America	261.2	338.4	341.8
Total	4 997.8	5 516.9	5 353.5
AUSTRALASIA			
Australia	259.3	265.3	283.0
Other Australasia	26.1	32.0	34.7
Total	285.4	297.3	317.7
TOTAL	**12 003.8**	**12 581.6**	**12 681.2**
Monthly Average	1 000.3	1 048.5	1 056.8
SOCIALIST COUNTRIES			
German D.R.	230.0	218.0	230.0
Hungary	181.7	195.3	188.6
U.S.S.R.	1 850.0	1 800.0	1 850.0
China	620.0	630.0	700.0
Other	487.0	481.7	488.4
Total	3 368.7	3 325.0	3 457.0
WORLD TOTAL	**15 372.5**	**15 906.6**	**16 138.2**

Source: World Bureau of Metal Statistics.

Antimony

J. BIGAUSKAS

Antimony is a silver-white, brittle metal generally found as the sulphide mineral stibnite Sb_2S_3, or its oxidized equivalents. It may also be present in variable amounts in lead ores, or in association with gold, tin tungsten and silver ores. High-grade lump ores are separated by hand cobbing - a relatively labour intensive method - while more disseminated ores are selectively processed by flotation and sold as concentrates. Concentrates typically contain about 60 per cent antimony by weight. Antimony in antimonial lead alloys is also widely recycled from lead-acid battery and other lead alloy scrap particularly outside of North America.

Major mine producers in the non-socialist world are Bolivia and the Republic of South Africa, while major producers in the socialist world are the People's Republic of China and the U.S.S.R.

CANADIAN DEVELOPMENTS

Between 1981 and 1985, primary antimony output in Canada was mostly a byproduct of the refining of lead. Cominco Ltd., which operates a lead smelter and refinery at Trail, British Columbia, produces antimonial lead, primarily from lead concentrates obtained from its Sullivan mine at Kimberley, British Columbia. Other sources are lead-silver ores and concentrates shipped to Trail by custom shippers. The lead bullion produced from these ores and concentrates contains a small amount of antimony which subsequently collects either in anode residues from the electrolytic refining of the lead bullion or in furnace drosses. These residues and drosses are treated to yield antimonial-lead alloy to which refined lead may be added to meet market requirements.

Lead concentrates produced by Brunswick Mining and Smelting Corporation Limited near Bathurst, New Brunswick, contain small amounts of antimony. Slag containing antimony and arsenic is removed by oxidation from lead bullion at the company's pyrometallurgical lead refinery at Belledune. The slag is fed into an antimony reverberatory furnace along with coke to produce lead bullion, which is returned to the lead refinery, and antimony-containing slag which is sold for upgrading elsewhere.

Operations at Consolidated Durham Mines & Resources Limited (renamed Durham Resources Inc. in 1984) near Fredericton, New Brunswick, ceased in 1981 when antimony reserves of the Hibbard orebody were exhausted. An extensive diamond drilling program initiated in 1980 and 1981 outlined a new antimony-bearing zone. Durham completed dewatering of the mine in September 1984 and began deepening the inclined shaft. The mill was restarted in June 1985 and reached rated capacity in late-1985. Mill capacity is about 500 tpd of ore or over 4 300 tpy antimony in a clean 65 per cent antimony concentrate. During 1986, production at 2 736 t of antimony in concentrate represented nearly 10 per cent of free world production. Sales are mainly to Europe and Japan.

Canadian consumption of antimony in 1985 was 195 t compared with 356 t in 1984. Antimony production in 1986 was valued at an estimated $24 million, up from $6.5 million in 1985.

WORLD DEVELOPMENTS

Major producers of antimony ores and concentrates are Bolivia and the Republic of South Africa, with 29 per cent and 25 per cent of western world production, respectively. Other producers include Mexico, Thailand and Yugoslavia, which collectively account for another 31 per cent. Large quantities of antimony are also exported by the world's largest producer, the People's Republic of China, to consumers around the world, including other socialist nations. The Xikuangshan mine in Hu-nan province is the

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largest single antimony producer. China sells antimony metal in three grades as well as antimony oxides and crude oxides. After a 10-year hiatus, the U.S.S.R. sold quantities of antimony metal to the west in 1986. In 1986, western world recoverable mine production is estimated at about 30 000 t of antimony in concentrates. An additional 20 000 tpy are produced by socialist countries.

Continuing industrial actions and uncertainties affected Bolivian output of antimony. Under the newly-elected government's austerity program, reorganization of Bolivia's mining sector was proposed in the late-summer of 1985. The plan, which was intended to reduce reliance on tin, was delayed for over a year. Protests by Bolivian mine workers culminated in the declaration of a state of emergency on August 28, 1986. Among the original terms of the proposal, Empresa Nacional de Fundiciones (ENAF), with antimony smelting facilities at Vinto Oro, would be folded into Corporacion Minera de Bolivia (Comibol), the state-owned mining company. Comibol in turn would be broken into four subsidiaries. ENAF is to be owned by Empresa Minera del Centro del Peru S.A. The largest privately-owned antimony producer, Empresa Minera Unificada S.A. (EMUSA), is not affected by the reoganization nor is the privately-owned Empresa Minera Bernal Hermanos, with its newly expanded antimony mine at Rosa de Oro, Tupiza. Bernal has the capacity to produce 600 tpy of antimony-lead alloy and 1 000 tpy of crude antimony oxide. By mid-September 1986, the Bolivian government agreed to modify plans to restructure Comibol in response to certain demands of the Bolivian Federation of Mine Workers relating mainly to mine operations. In October the Bolivian government announced that the World Bank would provide $US 45 million towards the reorganization of Comibol. In December the International Monetary Fund approved loans of SDR 106.7 million for general economic stabilization programs over the next three years.

Minas de Guatemala S.A. increased ore production from 1 200 tonnes per month (tpm) to 1 800 tpm with an average grade of 6 per cent antimony and 0.5 per cent lead. About 150 tpm of 62 per cent antimony concentrates (with 1 per cent combined arsenic-lead) are produced for sale in the United States, the United Kingdom and Japan. The operating rate may be increased to 165 tpm.

Mexico's Industrial Minera Mexico SA de CV is also a major integrated mine producer of antimony. It produces about 1 200 t of antimonial lead as a byproduct of lead-silver refining operations at Monterrey, plus about 2 000 tpy of antimony in concentrates.

The United States is not a major producer of antimony, but ASARCO Incorporated produces antimony concentrates from its Coeur mine at Wallace, Idaho. ASARCO's El Paso antimony plant was shut down in May, 1986. Coeur concentrates will be sent to the East Helena lead smelter and combined with lead feed. Antimony will then be recovered from lead bullion in the subsequent refining step and converted to antimony oxide at the company's Omaha, Nebraska refinery.

Amspec Chemical Corp. installed a second furnace for antimony trioxide production at its Gloucester City, New Jersey plant. It will utilise crude oxide and metal among other feed materials. Anzon America Inc. added a second blast furnace to its facilities at Laredo, Texas to allow various feeds to be utilised.

In the United States, recycling of antimony in lead-acid battery scrap and other lead scrap has declined in importance over the past decade due to replacement of antimonial lead with lead-calcium alloys in automotive batteries. Some producers report difficulty in obtaining good scrap. Antimonial lead scrap now being received contains less than 1 per cent antimony. Antimony metal must therefore be added for some applications.

On the other hand, European recycling of antimony is still extensive given the generally higher antimony content of lead-acid batteries and greater availability of other lead-alloy scrap such as cable covering which contains more antimony. Most antimony, antimonial lead and antimony oxides are produced as byproducts of lead refining operations. Feed materials include complex concentrates, lead bullion, residues, slimes, drosses, crusts, fumes, and scrap, as well as antimony metal or alloys. Some notable producers are Métallurgie Hoboken-Overpelt SA in Belgium (antimony metal capacity, 2 500 tpy), which produces from complex materials; Cie Chimique et Métallurgique Campine SA, Belgium (antimony metal and trioxide), which uses antimony ore and concentrate feeds; Preussag AG, West Germany (antimony metal, antimonial lead), which produces from lead concentrate, scrap and residue feeds; Norddeutsche Affinerie AG, West Germany (antimonial lead), from lead concentrates, complex materials, intermediate products and residues; Société minière et métallurgique de Penarroya S.A., France (antimony oxide, capacity 1 000 tpy; and antimonial lead); Mines & Produits chimiques de Salsigne S.A., France (antimony oxide, capacity 7 000 tpy) from antimony concentrates; and SAMIM S.p.A., Italy (antimony oxide, capacity 1 500 tpy, and antimonial lead, capacity 50 000 tpy). SAMIM S.p.A. recently completed a new 84 000 tpy KIVCET lead smelter which, when commissioned, could increase output substantially. Sour Rudarsko-Metalursko-Hemijski Kombinat Olova i Cinka (Trepca Works) in Yugoslavia extracts antimony metal from lead and zinc concentrates.

Consolidated Murchison Limited (RSA), the western world's largest primary antimony producer, recently upgraded its concentrator to increase production of antimony concentrates. Production fell from 16 599 t of concentrates and cobbed ore in reporting year 1981 to 12 060 t (58.2 per cent concentrate) in the year ending June, 1986. Milled tonnage increased from 388 950 t to 529 900 t in the same period. These divergent trends are the result of a drop in ore grades from 4.3 per cent antimony in 1981 to 2.3 per cent in 1986. Deepening of the Monarch East shaft and a 17-25 per cent pay increase for the National Union of Miners has increased expenses. Shaft sinking was completed in 1986, and the mine is expected to resume operations on March 1987. Consolidated Murchison owns 25 per cent of Antimony Products (Pty) Ltd., the antimony oxide producer at the mine site. Other 25 per cent owners were Cookson Group plc, McGean Chemical Co. Inc. and Laurel Industries Inc. In December 1986, Cookson Group merged its interest in the plant with Zimro (Proprietary) Group and retained a 45 per cent interest in the Zimro joint venture. Anglo American Corporation of South Africa Ltd. is the other major owner of Zimro. Most of Consolidated Murchison's concentrate is converted to crude antimony trioxide on behalf of overseas customers by Antimony Products. Most of this oxide is exported to the United Kingdom and North America.

The Government of Thailand approved plans to build a new antimony smelter near Bangkok at a cost of $US 1.7 million. The New Siam Mineral Resources Co., a state-owned venture, expects to produce some 1 000 tpy of antimony for export. Associated Minerals Consolidated Ltd. announced in mid-1985 that it expects to produce 4 000-20 000 tpy of antimony concentrate from a new mine in southeast Chonburi province beginning in 1988. Associated Minerals Consolidated Ltd. is owned 44.1 per cent by BP Minerals International Ltd., 45.9 per cent by Siam Cement Co., and 10 per cent by the Thai government.

Japanese metallurgical works, like most European plants, produce antimony oxides from a variety of sources including concentrates and antimony-containing metallurgical byproducts. Producers include major lead refiners such as Mitsubishi Metal Corporation and Nippon Mining Co. Ltd. Dowa Mining Co., Ltd. started production of antimony trioxide in 1985 at its Kosaka plant. Japanese metallic antimony production fell by 41.8 per cent to 129 t in the first nine months of 1986 compared with the same period of 1985, while antimony trioxide production rose by 11.6 per cent to 6 980 t. Japanese consumption of antimony metal is mainly supplied by imports. Imports in 1986 are estimated at 3 700 t, down 13 per cent from 4 269 t in 1985.

STOCKS

In the United States, a joint House-Senate bill was sent to the U.S. President in October, 1986 as an answer to the Administration's 1985 proposal to adopt the U.S. National Security Council (NSC) recommendations for modernization of the strategic and critical materials stockpile. Tier I and Tier II classifications were proposed in the NSC proposal. Antimony, a Tier I material, would be one of several required by military, industrial and essential civilian users during a military conflict or one that would not be available from domestic or reliable foreign sources. Tier II would be supplemental to Tier I. The Tier I goal for antimony is 4 159 t (4,585 short tons). The bill would allow disposal of 1 361 t (1,500 short tons) of antimony. House provisions were included that would waive the stockpile transaction fund ceiling of $250 million for fiscal year 1987 only; on October 1, 1988, the ceiling will fall to $100 million to prevent a higher rate of sales. A proposal for revised management of the U.S. stockpile was also made. On June 9, 1986 the U.S. General Services Administration announced a first sale of excess antimony from the U.S. National Defense Stockpile as tender in a continuing effort to upgrade ferroalloy stocks. As of December 31, 1986, antimony metal in the stockpile totalled 33 910 t (37,379 short tons) and the goal was 32 660 t (36,000 short tons).

PRICES

European Free Market prices, as reported by Metal Bulletin (for Regulus, minimum 99.6 per cent antimony, fob warehouse), fell from $US 2,740-2,800 per t at the end of 1985 to $2,300-2,425 by mid-August 1986. The price firmed to $2,550-2,700 by mid-October 1986 before falling to $US 2,300-2,360 at the end of 1986.

The monthly average Metals Week, New York Dealer Price rose slightly from $US 1.31/lb in January 1986 to $1.35 in April 1986 before falling to $1.07 in August. The average improved to $1.19 in October 1986 and then fell to $US 1.11 in December 1986.

USES

Antimony is used principally in the form of oxides and alloys. In alloys, antimony hardens and strengthens lead and inhibits chemical corrosion. These characteristics created a large use for the metal in lead-acid storage batteries. However, the introduction of the low antimonial-lead alloys and calcium-lead alloys has reduced this application, particularly in North America. Antimonial-lead alloys are also used for power transmission and communications cable sheathing, type metal, solder, ammunition, chemical pump and pipe linings, tank linings, sheets and anti-friction bearings.

Antimony trioxide, pentoxide and oxy-chloride, and sodium antimonate are used as fire retardants or stabilizers in plastics, textiles and rubber. Fire retardants are now the largest end use for antimony.

Antimony trioxide or sodium antimonate are also used as refining and decolouring agents in certain types of glass. Sodium antimonate is normally used in the manufacture of television screens. Antimony trioxide is also used in the manufacture of white pigments. Antimony pentasulphide is a vulcanizing agent for the production of red rubber compounds. Burning antimony sulphide creates a dense white smoke for use in sea markers, signalling and fireworks.

High-purity metal is used in the production of indium antimonide and aluminum antimonide intermetallic materials for semi-conductors.

OUTLOOK

Despite promising growth in antimony fire retardants and the fact that this use is not subject to recycling, the potential for non-market sensitive supplies of antimony in its various forms is still large. Expansions by western world producers, while not likely to be a major source of market instability, must nevertheless be paced to match growth in antimony use and prevent additional instability. As for every metal, research and development, particularly for broad and dissipative uses, can contribute positively to long-term stability of the market - a feature that is desirable for producer and consumer alike. The trend towards producing upgraded antimony products by major producers, including the People's Republic of China, will likely mean increased competition for metal and oxide producers. Nevertheless, the outlook for mine producers remains relatively favourable in the medium-term.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			%		
CANADA					
33000-1	Antimony or regulus of, not ground, pulverized or otherwise manufactured	free	free	free	free
33502-1	Antimony oxides	free	free	1.6	25
MFN Reductions under GATT (effective January 1 of year given)			1986	1987	
33502-1			1.6	free	
UNITES STATES (MFN)					
			(¢ per pound)		
601.03	Antimony ore		Remains free		
632.02	Antimony metal unwrought, etc.		0.1	free	
EUROPEAN ECONOMIC COMMUNITY (MFN)			1986		
26.01	Antimony ore		free		
81.04	1. Antimony unwrought; waste and scrap		free		
	2. Antimony, other		8		

Sources: The Customs Tariff, 1986, Revenue Canada, Customs and Excise. Tariff Schedules of the United States Annotated (1986), USITC Publication 1775; U.S. Federal Register Vol. 44, No. 241; Official Journal of the European Communities, Vol. 28, No. L331, 1986.

TABLE 1. CANADA, ANTIMONY PRODUCTION AND IMPORTS, 1985 AND 1986 AND CONSUMPTION, 1984 AND 1985

	1985		1986P	
	(tonnes)	($000)	(tonnes)	($000)
Production				
New Brunswick	..	2,605	..	20,444
British Columbia	..	3,872	..	3,466
Total	..	6,477	..	23,910
Imports				
			(Jan. - Sept.)	
Antimony oxide				
United States	534	2,410	569	2,211
United Kingdom	570	2,866	300	1,373
Belgium-Luxembourg	72	337	28	137
France	11	27	-	-
Total	1 187	5,640	897	3,721
Antimony, primary forms and fabricated materials				
United States	120	494	160	621
People's Republic of China	1	4	38	152
France	-	-	4	10
Netherlands	18	68	-	-
Total	139	566	202	784

	1984	1985P
	(kilograms)	
Consumption[1]		
Antimony metal used for, or in the production of:		
Antimonial lead	262 020	111 743
Babbit	13 345	10 508
Type metal	5 620	4 156
Solder	5 797	1 749
Other commodities	69 490	67 137
Total	356 272	195 293
Held by consumers on December 31[2]	34 474	25 312

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Antimony content of primary and secondary antimonial-lead alloys. [2] Available data, as reported by consumers.
P Preliminary; .. Not available due to confidentiality; - Nil.

TABLE 2. CANADA, CONSUMPTION AND CONSUMERS' STOCKS OF ANTIMONY[1], 1970, 1975, AND 1980-85

	Consumption		On hand at end of year	
	Antimony metal	Antimonial-lead alloy[2]	Antimony metal	Antimonial-lead alloy[2]
	(kilograms)			
1970	518 007	635 212	131 501	91 563
1975	454 164	723 155	116 760	170 478
1980	369 732	643 983	42 389	51 405
1981	209 829	691 180	35 105	151 400
1982	161 034	605 502	39 799	76 979
1983	217 352	560 705	26 106	130 104
1984	356 272	648 413	34 474	23 319
1985P	195 293	826 846	25 312	20 298

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Available data, as reported by consumers. [2] Antimony content of primary and secondary antimonial-lead alloys.
P Preliminary.

TABLE 3. WORLD MINE PRODUCTION OF ANTIMONY, 1983-85

	1983	1984	1985
		(tonnes)	
Europe	**2 520**	**2 266**	**2 894**
Austria	970	523	477
France	111	-	-
Italy	339	-	542
Spain	489	554	554
Yugoslavia	950	945	1 321
Africa	**6 899**	**8 633**	**8 514**
Morocco	454	994	994
South Africa	6 302	7 509	7 390
Zimbabwe	143	130	130
Asia	**2 932**	**3 099**	**3 032**
Malaysia	133	17	27
Pakistan	-	5	5
Thailand	1 740	2 874	2 800
Turkey	1 059	203	200
America	**14 569**	**14 356**	**14 476**
Bolivia	9 951	9 281	8 635
Canada	454	554	1 094
Guatemala	500	92	90
Honduras	10	320	320
Mexico	2 519	3 064	3 574
Peru	375	540	263
United States	760	505	500
Oceania			
Australia	538	900	900
Total	27 458	29 254	29 816
Other			
China, P.R.	13 000	13 500	17 721[1]
Czechoslovakia	900	1 000	..
U.S.S.R.	6 500	6 500	..
Other	500	450	..

Source: World Metal Statistics.

[1] Exports only.

- Nil; .. Not available.

TABLE 4. INDUSTRIAL CONSUMPTION OF PRIMARY ANTIMONY IN THE UNITED STATES BY PRODUCT PRODUCED, 1984 AND 1985

	1984	1985
	(tonnes)	
Metal Products		
Ammunition	W	372
Antimonial lead	766	515
Bearing metal and bearings	165	156
Cable covering	W	W
Castings	10	10
Collapsible tubes and foil	W	W
Sheet and pipe	72	W
Solder	210	307
Type metal	28	28
Other	306	95
Nonmetal Products		
Ammunition primers	19	24
Fireworks	6	4
Flame-retardants	7 220	6 831
Ceramics and glass	1 172	1 077
Pigments	161	133
Plastics	1 005	905
Rubber products	19	23
Other	146	128
Total	11 308	10 615

Source: U.S. Bureau of Mines.
W - Withheld, confidential.

TABLE 5. ANTIMONY PRICES, NEW YORK DEALER[1]

	1984	1985	1986
		($US/lb)	
January	1.26	1.30	1.31
February	1.24	1.26	1.32
March	1.52	1.36	1.33
April	1.56	1.35	1.35
May	1.62	1.32	1.34
June	1.56	1.27	1.27
July	1.52	1.34	1.08
August	1.60	1.33	1.07
September	1.65	1.28	1.10
October	1.65	1.33	1.19
November	1.56	1.30	1.16
December	1.40	1.28	1.11
	1.51	1.31	1.22

Source: Metals Week.

[1] 99.5 - 99.6 per cent metal, cif U.S. ports, 5 ton lots, duty paid.

Arsenic

D.G. LAW-WEST

Arsenic occurs as a minor constituent of complex ores mined primarily for their copper, lead, zinc, silver or gold content. Globally, copper ores are the main source of arsenic. The arsenic is usually recovered from dusts and residues associated with the roasting of these ores. It is collected as an impure arsenic trioxide which is either purified on site or sold directly to a refiner. Ninety-six per cent of arsenic is consumed as arsenic trioxide or another arsenic compound. Only 4 per cent is consumed as metallic arsenic. In the literature, arsenic trioxide is commonly referred to as arsenic.

The demand for arsenic has been somewhat stagnant over the past few years, with the price remaining around $US 0.42/lb. since 1985. Environmental concerns about the use of arsenic in agricultural herbicides, dessicants and insecticides greatly reduced its demand in the early 1980s. The wood preservatives industry, which created a brief supply shortage in the late 1970s, remains the largest single consumer of arsenic.

CANADIAN DEVELOPMENTS

Canadian arsenic production is obtained mainly as arsenic trioxide from the treatment of arsenious gold ores. Production declined to 5 100 t in 1986 from 8 400 t in 1985.

Campbell Red Lake Mines Limited in Ontario and Giant Yellowknife Mines Limited in the Northwest Territories recover impure arsenic trioxide from dust and residues collected during the roasting of gold ores. They use similar recovery technology, including electrostatic precipitation of dust, cooling of the arsenic-containing gases and collection of arsenic trioxide in a baghouse.

Campbell Red Lake recovers about 1 400 tpy of product grading 90 to 93 per cent As_2O_3 and ships it to the United States for further processing. Giant Yellowknife had been shipping a similar product grading 85 to 93 per cent to the United States, but has discontinued the practice pending improved market conditions. The company is stockpiling its arsenic output underground.

Cominco Ltd. closed the 12 tpd arsenic trioxide plant at its Con mine near Yellowknife late in 1985 and converted it into a water treatment plant. After operating it as such for most of 1986, the company modified the process configuration and planned to reconvert to arsenic trioxide production grading 99.5 per cent by early 1987. However, late in 1986, Cominco sold the Con mine and associated arsenic trioxide recovery plant to NERCO Minerals Company of Fairbanks, Alaska for some $64 million.

INTERNATIONAL DEVELOPMENTS

ASARCO Incorporated halted the production of arsenic metal and arsenic trioxide at its copper smelter in Tacoma, Washington at the end of 1985. Some shipments of these products continued into 1986. The main reason given for the shutdown was the high cost of bringing the smelter into compliance with environmental regulations.

Boliden Aktiebolag in Sweden, with a capacity of 15 000 tpy, is the western world's largest arsenic producer. Arsenic trioxide accounts for 70 to 80 per cent of production while arsenic metal and arsenic acid production varies from 10 to 15 per cent depending on product demand.

The El Indio mine in Chile recovers about 4 800 tpy of 97 per cent grade arsenic trioxide from the roasting of its copper ores.

USES

In 1985, about 62 per cent of arsenic was used in industrial chemicals, mainly wood preservatives, 30 per cent in agricultural chemicals, 4 per cent in glass manufacturing, 3 per cent in nonferrous alloys and 2 per cent in other uses. The United States is the largest consumer of arsenic, using over 50 per cent of the world production.

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In the past decade, consumption by the wood preserving industry has risen from less than 2 per cent to over 60 per cent of arsenic production. Chromated copper arsenate (CCA) is by far the most common of the arsenical wood preservatives. Ammoniacal copper arsenide (ACA) and fluor chrome arsenate phenol (FCAP) are two other less widely used wood preservatives. Waterborne CCA chemically reacts with the wood substrate and fixates in the form of a leach-resistant compound. Arsenical wood preservatives are used wherever rot or insect damage may occur such as in building foundations, fence posts, submerged footings and utility poles.

The agricultural share of arsenic use has dropped from over 80 per cent a decade ago to the current 30 per cent. Monosodium methanearsenate (MSMA) and disodium methanearsenate (DSMA) are the most common agricultural arsenical chemicals. These compounds are used as herbicides and plant desiccants and defoliants primarily in the cotton industry where they are used to control grassy and broad-leaved weeds.

The glass industry uses arsenic trioxide as a decolorizing agent and to remove tiny air bubbles in the glass. Because of environmental concerns the glass industry has been substituting arsenic acid for arsenic trioxide to reduce dust problems associated with handling the latter.

Arsenic metal is used as a minor (0.01 to 0.5 per cent) alloying agent in certain copper and lead based alloys. When added to lead for use in acid storage batteries, arsenic strengthens the lead posts and grids to help withstand sudden jars. Arsenic increases the corrosion resistance and tensile strength of copper used in industrial plant piping and auto radiators. Arsenic trioxide can also be used in some alloying applications.

High purity arsenic metal (99.999 per cent) is used in the electronics industry. Gallium arsenide and its alloys are important semiconductors and are used in such products as light-emitting diodes, microwave devices, solar cells and photoemissive surfaces. Gallium arsenides have higher operating frequencies, lower power consumption, lower noise and higher resistance to nuclear radiation than their silicon counterparts. Integrated circuits using gallium arsenide have extensive military applications.

OUTLOOK

The outlook for arsenic is somewhat uncertain. As a by-product, its production is largely a function of the demand for other metals and does not respond directly to changes in the demand for arsenic. Environmental concerns could adversely affect the demand for arsenic and arsenical products as seen in the marked drop in agricultural uses.

The closure of ASARCO's arsenic trioxide plant had only a brief impact on arsenic prices, which have remained unchanged during the last two years. There is no reason to expect any price change during the short to medium term. The wood preservative industry, the largest consumer of arsenic, is well established and is not likely to expand over the next few years.

TABLE 1. WORLD PRODUCTION OF ARSENIC TRIOXIDE (WHITE ARSENIC), 1970, 1975, 1980, 1984-86

	1970	1975	1980	1984	1985	1986*
			(tonnes)			
U.S.S.R.	7 149	7 348	7 711	7 257	7 257	7 257
Mexico	9 140	6 121	6 532	4 082	4 082	4 535
France	10 193	8 165	5 262	4 536	5 443	7 257
Sweden	16 400	15 967	4 082	5 352	5 443	6 350
Canada	5 000	5 000	5 000	8 000	8 000	5 100
Namibia	4 062	6 663	1 996	2 272	2 268	2 268
Others	16 223	14 340	6 262	5 144	8 165	13 000
Total	68 167	63 604	36 845	37 043	37 759	45 767

Source: U.S. Bureau of Mines, Mineral Commodity Summaries.
Note: Canadian production, estimated by the Mineral Policy Sector of Energy, Mines and Resources Canada, includes material stockpiled in crude form.
* Estimated.

Asbestos

G.O. VAGT

Canadian shipments of asbestos (chrysotile) in 1986 were lower for several reasons including the closure of one mine, foreign exchange shortages in the developing countries, uncertainties regarding future regulations, and adverse publicity associated with past exposure to asbestos dust in the workplace. Total shipments in 1986 were 640 000 t valued at $300.6 million compared to 750 190 t valued at $298.6 million in 1985.

Since 1981, greatly reduced mine production coupled with large inventories have resulted in shortened work periods, layoffs, prolonged shutdowns, and permanent closures. Employment in the industry has declined to about 3,000 from over 8,000 in 1979. Exports, generally accounting for about 95 per cent of production, amounted to 526 000 t valued at $292 million during the first 9 months of 1986, compared to 554 000 t valued at $343 million during the same period in 1985.

The International Labour Organization (ILO) voted overwhelmingly in favour of the International Convention on Safety in the Use of Asbestos. This marks a turning point in the international controversy over asbestos use as it serves to emphasize that with proper controls and regulations asbestos (chrysotile) can be used safely.

Canada takes the position that with enforcement of appropriate regulations to rigourously control exposure to asbestos dust the risks associated with chrysotile in mining, milling, product manufacture, transportation and handling can be reduced to acceptable levels.

CANADIAN DEVELOPMENTS

A consolidation of mining and milling operations at Thetford Mines-Black Lake was formalized in mid-year. The resulting limited partnership, known as LAB Chrysotile Inc., involved reorganization of production and sales of Lake Asbestos of Quebec, Ltd. (LAQ), Asbestos Corporation Limited and Bell Asbestos Mines, Ltd.; the latter two companies were controlled by Société nationale de l'amiante (SNA), a Quebec Crown corporation. The resulting partnership, with its stated goals of reducing production costs and improving international competitiveness, now controls about 50 per cent of asbestos production in Quebec.

Carey Canada Inc., a subsidiary of Miami based Jim Walter Corporation, closed its mining and milling operation at East Broughton, Quebec, in April. The mine began large-scale production in 1958 mainly producing fibre groups 6 and 7 for the United States market. Sales fell from about 210 000 t to 70 000 t a year between 1979-80 and 1985. A total of about 170 employees were affected.

Cassiar Mining Corporation started a $4 million underground exploration and development program to confirm reserves at its new McDame asbestos deposit that could probably be mined by low-cost block-caving methods. The present Cassiar open-pit will be exhausted in 1991 and work in 1986 may allow a production decision in the near future.

At the Jeffrey mine, owned by J M Asbestos Inc., the present mining plan should ensure continued operation until the end of this decade; plans for future development are under study. There were no further layoffs, in fact some workers were recalled as a result of increased demand for short fibres.

The Montreal-based Asbestos Institute, funded by contributions from the Governments of Canada and Quebec and most asbestos mining companies, continued its activities dedicated to promoting the safe use of asbestos in Canada and throughout the world. During the last two years, the priority has been on the regulatory front, where major efforts continue to be made to promote the international harmonization of asbestos regulations based on the controlled-use approach. Paralleling this effort were

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major initiatives in the areas of market development, technical services and research and development.

The Government of Quebec announced in July plans to privatize two of SNA's manufacturing subsidiary companies. By year-end a total of five subsidiaries had been privatized. In keeping with an overall plan to reduce expenditures, rationalisation of R&D activities will also be addressed. Under a complex contract signed in 1981 by the previous Government of Quebec and General Dynamics Corporation (GDC), Quebec completed its purchase of GDC's holdings in Asbestos Corporation Limited for an overall cost of about $180 million.

Reported consumption of asbestos in Canada dropped from about 27 000 t in 1982 to about 20 000 t in 1985. Related statistics in Table 5 are reported in three categories to protect company confidentiality.

HEALTH AND REGULATIONS

Federal emission regulations pursuant to the Clean Air Act as defined by Environment Canada require that the concentration of asbestos fibres contained in emissions to the ambient air shall not exceed 2 fibres per cubic centimetre (f/cm^3). This level is being re-examined in conjunction with drafting of the new Environmental Protection Act. Labour Canada is expected to lower the exposure limit for chrysotile to 1.0 f/cm^3 in numerous sectors where it has jurisdiction.

Consumer and Corporate Affairs Canada introduced a proposal under the Hazardous Products Act to ban the sale of loose asbestos to the general public. The proposal applies to asbestos fibres including actinolite, amosite, anthophyllite, chrysotile, crocidolite, cummingtonite and tremolite, as well as to fibrous erionite, a member of the zeolite family of minerals.

At a federal/provincial labour ministers meeting held in November, 1986, the ministers agreed to the ratification by Canada of the International Labour Organization (ILO) Convention on Safety in the use of Asbestos, subject to clarification of certain requirements of the Convention and the formal approval of their respective cabinets.

The Ontario Ministry of Labour "Regulation Respecting Asbestos on Construction Projects and in Buildings and Repair Operations" became effective in March. This culminates a program to establish a safe, practical construction-related asbestos regulation under the Ontario Occupational Health and Safety Act.

Media reports in Winnipeg, Manitoba resulted in concern about asbestos fibres in drinking water, however more factual information later showed that concerns were misplaced. In any case, the city published a factsheet emphasizing that health risks associated with ingestion of low levels of asbestos are negligible.

WORLD DEVELOPMENTS AND INTERNATIONAL REGULATIONS

Based on an estimated 1985 world production of 4.1 million t of fibre, major producers and their approximate percentage share of production are: U.S.S.R., 58; Canada, 18; and Republic of South Africa, Zimbabwe and Brazil, each 4. In terms of trade, however, Canada remains the most important exporter providing more than 40 per cent of world imports of asbestos. Expansions to production facilities in the Soviet Union are reportedly to serve domestic needs of industrial and residential construction.

The U.S. Environmental Protection Agency (EPA) published a proposed rule on January 29th intended to ban the use of certain asbestos-containing products and phase out remaining uses in the United States over a 10-year period. As provided for under the Toxic Substances Control Act, public hearings on the proposed rule were held in July and cross-examination hearings were held in October. Industry responded by calling on EPA to withdraw its proposal on the basis that the supporting documents are legally deficient. It would appear that a final rule, or possibly a new proposal, will not be issued before December, 1987.

The U.S. Occupational Safety and Health Administration announced a new asbestos standard of 0.2 f/cm^3 for both manufacturing and construction industries effective in July, 1986. This is a 10-fold reduction from the 2 f/cm^3 standard established in 1976; these revised standards were immediately challenged, though for different reasons, by industry and labour. Several petitioners filed opening briefs in October 1986, to the Washington circuit appeals court.

The International Labour Organization, representing about 140 countries, in almost unanimous fashion adopted. in June, a Convention and Recommendation on Safety in the Use of Asbestos. The principle of controlled-use was endorsed, and while strict in terms of measures required for worker protection, the Convention does not call for prohibition or mandatory replacement of chrysotile asbestos. Also, a resolution was adopted calling on the ILO to establish a group of experts to examine potential health hazards associated with all fibrous materials, including asbestos substitutes, and to develop any relevant instruments for these materials.

At an international symposium in Copenhagen sponsored by the World Health Organization, it was confirmed that certain synthetic fibrous materials increase risks of lung cancer in workers engaged in their manufacture. Advice given by the World Health Organization in its 1980-82 Guidelines for Drinking-Water Quality remain valid. Based on scientific studies published since 1981, there seems to be a growing consensus that variable concentrations of asbestos in drinking water are not carcinogenic and do not pose a health hazard.

Adverse publicity often associated with asbestos in buildings continued in the United States. This health-related issue has apparently not been resolved, although detailed studies elsewhere have indicated that the environmental health risk from asbestos in buildings is of an extremely low order. Exceptions have been found where loose asbestos is being actively disturbed or is falling.

In the European Community, the EC Council Directive approved in 1983 on Protection in the Workplace 83/478/EEC, provided the basis on which member states are to adopt compliance laws before January 1, 1987. The control limit for exposure to asbestos other than crocidolite, over an eight-hour sampling period, will be 1 f/cm^3; for crocidolite the limit value will be 0.5 f/cm^3.

A subsequent EC directive on Marketing and Use 76/769/EEC, issued in 1985, limited a number of asbestos-containing products as follows: toys; materials for spray-on application, except undercoatings for cars; products distributed in powder form (spackling compounds); items for smokers such as tobacco pipes and cigarette and cigar holders; catalytic filters and insulation devices for certain catalytic heaters and paints and varnishes. Based on the regulatory approach to date, the EEC philosophy currently accepts that there is no undue health risks at low levels of exposure and that asbestos exposure is primarily an occupational problem rather than an environmetal hazard.

In the Federal Republic of Germany there has been considerable pressure to introduce restrictive regulations against the use of asbestos rather than to follow a controlled-use approach. Regulations and voluntary agreements with asbestos-consuming industries mandate some replacement and substitution.

In France there has been agreement for some time that it is possible to work safely with asbestos, provided the strictest of measures are applied to ensure that controlled-use prevails. The first International Conference on Asbestos-Cement, held in Cannes, highlighted information on new and improved applications of asbestos-cement products as well as recent technological innovations aimed at improving the properties of these relatively low-cost materials.

Denmark gave official notice to the GATT Committee on Technical Barriers to Trade of its intent to ban asbestos in brake components of light vehicles and some heavy vehicles and in transmission systems in light vehicles. The new regulations would apply to vehicles registered or taken into use for the first time beginning in April, 1988.

PRICES AND CONSUMPTION

Average real prices for asbestos have fallen since the 1980-81 period. Weakness in the construction sector, which accounts for an estimated 75 per cent of worldwide demand, along with some emphasis on using asbestos-free products where possible, have greatly increased competition among producers.

In addition to price discounting among domestic producers, there was aggressive price competition from Brazil, Zimbabwe and Greece. Countertrade was an important factor in some markets.

Alternate Fibres and Materials

The controversy over health and stricter regulations on use have resulted in much promotion of alternate fibres and products which have made significant inroads.

Asbestos-cement products are particularly competitive in the developing countries where locally purchased raw materials (assuming a cement: silica sand ratio of 60:40) are available at an average price of much less than $100/tonne. Although most synthetic fibres do not have the same reinforcing characteristics as group 4 chrysotile, success has been achieved with cellulose fibres particularly for flat sheets where reinforcing ability is less critical and in regions, e.g. tropics, where there is little temperature variation.

RESEARCH AND DEVELOPMENT

CANMET's Asbestos R&D involves three programs; Respirable Dust in Asbestos Mills, Asbestos Cement Products and Productivity Improvements. The programs are conducted under various contracts, valued at approximately $260,000 a year. Results to date have been recently reported in CANMET publication No. MSL 86-124 (OP&J).

A portable, inexpensive asbestos fibre monitor being developed under contract will allow measurements of asbestos fibres at levels below 1 f/cm^3 in the workplace. Following development by the contractor, accuracy tests in Quebec mills are scheduled for 1987.

Atlas Turner Inc. has developed formulations for improved A/C cooling tower fill, using fly ash and silica fume as supplements to cements and asbestos.

Cassiar Mining has developed a wet asbestos process using CANMET technology and is mid-way through a $1.2 million Program for Industry/Laboratory Projects (PILP) agreement. The fibre produced from tailings has extremely low fines content and cost studies indicate that a wet process would operate with 40 per cent lower capital and operating costs. The pilot plant continued to evaluate various equipment for fibre grading, water recycling, and fibre characterization. Also, samples were produced for customer evaluation.

Health and Welfare Canada recognizes that there should be toxicological testing of replacement materials. It has recommended to federal and provincial occupational health authorities that exposure to all fibrous dusts in the workplace be minimized through introduction of suitable industrial hygiene measures.

The importance of R&D to the future of the industry was discussed in October at a symposium on technological research organised by the Government of Quebec (Centre de recherches minérales). An agreement between industry, governments and certain institutions will be sought on the orientation, organization and financing of all asbestos R&D.

> For further information relating to CANMET R&D on asbestos, contacts are: D. Doyle, 613-992-7782 and P. Mainwaring, 613-995-4608.

OUTLOOK

Weak demand and prices are expected to continue, however partial consolidation of mining and milling operations in Quebec should lower production costs allowing companies to sell more competitively.

Canadian mine production during this decade is forecast to continue at today's depressed level, or to fall even lower depending on the extent of restrictive regulations abroad.

The ILO's International Convention on Safety in the Use of Asbestos is considered a major turning point in regulatory trends because it endorses the view that chrysotile asbestos, with proper controls, can be used safely.

Although the outlook remains uncertain particularly in the United States, it appears that the direction of EPA's regulatory initiatives may be revised in light of more complete studies. With more comprehensive data, it may be that the EPA will move closer to a "controlled-use" regulatory approach.

Although there are well-established needs for asbestos-cement products in construction and irrigation projects in the developing countries, foreign exchange and debt problems will continue to be major obstacles to trade.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
CANADA					
			(%)		
31200-1	Asbestos, in any form other than crude, and all manufactures thereof, nop	8.6	8.6	25	5.5
31205-1	Asbestos in any form other than crude, and all manufactures thereof, when made from crude asbestos of British Commonwealth origin, nop	free	8.6	25	free
31210-1	Asbestos, crude	free	free	25	free
31215-1	Asbestos, yarns, wholly or in part of asbestos, for use in manufacture of clutch facings and brake linings	5.8	5.8	25	3.5
31220-1	Asbestos woven fabric, wholly or in part of asbestos for use in manufacture of clutch facings and brake linings	8.6	8.6	30	5.5
31225-1	Asbestos felt, rubber impregnated for use in manufacturing floor coverings	free	free	25	free

MFN REDUCTIONS (effective January 1 of year given)	1986	1987
	(%)	
31200-1	8.6	8.0
31205-1	8.6	8.0
31215-1	5.8	5.5
31220-1	8.6	8.0

UNITED STATES

518.11	Asbestos, not manufactured, crudes, fibres, stucco, sand and refuse	free
518.41	Asbestos cement pipes, tubes and fittings	0.15¢ per lb
518.44	Other asbestos cement articles	free

		1986	1987
		(%)	
518.21	Asbestos, yarn, slivers, rovings, wick, rope, cord, cloth, tape and tubing	0.5	free
518.51	Asbestos articles nop	0.6	free

Sources: The Customs Tariff, 1986, Revenue Canada: Customs and Excise. Tariff Schedules of the United States, Annotated (1986) USITC Publication 1775. U.S. Federal Register Vol. 44, No. 241.
nop Not otherwise provided for.

TABLE 1. CANADA, ASBESTOS PRODUCTION AND TRADE, 1984-86

	1984		1985		1986P	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Production (shipments)[1]						
By type						
Group 3, spinning	15 502	19,771	13 537	14,405	..	..
Group 4, shingle	251 546	180,383	233 969	150,676	..	..
Group 5, paper	175 455	95,960	150 223	63,729	..	..
Group 6, stucco	167 429	50,121	160 457	43,464	..	..
Group 7, refuse	226 722	33,040	192 004	26,322	..	..
Total	836 654	379,275	750 190	298,596	640 000	300,586
By province						
Quebec	690 678	278,640	615 719	223,622	515 000	232,986
British Columbia	92 123	75,296	89 350	56,715	80 000	49,600
Newfoundland	53 853	25,339	45 121	18,259	45 000	18,000
Total	836 654	379,275	750 190	298,596	640 000	300,586
Exports					**(Jan. - Sept.)**	
Crude (unspecified)						
Japan	25	24	521	164	19	15
United States	20	3	20	17	-	-
United Kingdom	2	11	-	-	-	-
Singapore	-	-	-	-	-	-
Argentina	-	-	20	15	-	-
Belgium-Luxembourg	17	4	-	-	-	-
West Germany	53	62	-	-	-	-
Other	-	-	21	7	108	59
Total	167	104	582	203	127	74
Milled fibre (groups 3, 4 and 5)						
West Germany	21 735	21,330	23 399	22,309	25 082	21,220
Japan	33 679	26,139	33 745	25,632	25 878	18,507
United States	48 178	45,473	31 986	31,721	17 109	14,709
France	30 107	25,234	14 403	13,650	22 079	15,721
India	30 716	25,653	32 094	23,532	11 324	7,452
United Kingdom	20 425	20,805	15 150	15,886	11 236	10,222
Mexico	17 607	16,745	17 836	15,228	6 526	5,163
Italy	18 731	19,112	24 514	23,214	18 431	15,794
Australia	10 463	11,152	7 260	7,513	3 770	3,237
Malaysia	7 059	6,566	5 110	4,755	3 350	5,877
Thailand	19 167	13,832	21 487	14,580	13 435	8,269
Spain	3 914	3,752	10 463	9,095	9 405	5,683
Belgium-Luxembourg	8 440	8,270	6 928	6,766	4 900	4,140
Austria	11 858	10,519	9 117	8,313	7 976	6,351
Other countries	148 312	136,757	141 695	128,354	92 727	73,987
Total	430 391	391,339	395 127	350,548	273 228	216,332
Shorts (groups 6 and 7)						
United States	137 023	31,574	101 084	21,963	72 720^e	15,418
Japan	65 583	19,876	66 229	20,372	59 401	19,241
United Kingdom	11 543	3,442	12 429	4,601	7 614	2,345
West Germany	14 757	4,935	10 469	3,834	12 146	4,790
France	6 297	1,558	4 653	1,035	2 927	865
Mexico	8 229	2,036	9 334	2,552	4 852	1,071
India	10 057	3,483	14 085	5,050	7 625	3,093
Thailand	16 903	7,599	11 277	4,601	7 332	2,982
Taiwan	15 771	6,917	10 765	4,609	12 261	4,790
South Korea	14 722	3,562	18 393	5,303	17 986	5,631
Belgium-Luxembourg	7 639	3,285	6 397	2,114	5 202	1,684
Venezuela	4 728	1,091	1 850	434	2 202	430
Argentina	6 771	2,026	1 833	479	2 886	750
Nigeria	1 619	499	3 018	1,107	-	-
Switzerland	200	48	345	80	-	-
Other countries	44 364	15,611	54 133	17,614	37 160	12,133
Total	366 206	107,542	326 294	95,768	252 234^e	75,223
Grand total crude, milled fibres and shorts	796 764	498,985	722 003	446,519	525 589^e	291,629

TABLE 1. (cont'd)

	1984		1985		1986P	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Manufactured products						
Asbestos cloth, dryer felts, sheets						
United States		1,233		847		578
United Kingdom		462		482		414
Japan		2		70		-
Other countries		620		214		50
Total		2,317	..	1,613	..	1,042
Brake linings and clutch facings						
United States		8,602		7,943		1,975
Australia		111		55		-
Hong Kong		76		3		-
West Germany		60		59		-
France		-		45		-
Other countries		91		58		13
Total		8,940	..	8,163	..	1,988
Asbestos and asbestos cement building materials						
United States		7,555		7,420		5,470
United Kingdom		363		208		-
Australia		164		223		173
Singapore		129		111		-
Venezuela		165		152		143
Egyptian A.R.		23		-		90
Indonesia		57		117		191
South Africa		43		-		-
Malaysia		48		24		-
Other countries		165		862		535
Total		10,198	..	9,117	..	6,602
Asbestos basic products, nes						
United States		2,842		2,531		1,121
West Germany		704		71		95
Australia		16		-		-
Mexico		134		96		-
Other countries		523		797		456
Total	..	4,219	..	3,495	..	1,672
Total exports, asbestos manufactured	..	25,674	..	22,388	..	11,304
Imports						
Asbestos, unmanufactured	126	505	374	635	251	491
Asbestos, manufactured						
Cloth, dryer felts, sheets, woven or felted		1,114		774		914
Packing		2,741		2,681		1,711
Brake linings		21,245		20,732		16,159
Clutch facings		2,078		2,109		1,541
Asbestos-cement shingles and siding		91		34		18
Asbestos-cement board and sheets		515		692		254
Asbestos building materials, nes		1,495		1,071		730
Asbestos basic products, nes		1,022		1,257		956
Total asbestos, manufactured	..	30,301	..	29,350	..	22,283
Total asbestos, unmanufactured and manufactured	..	30,806	..	29,985	..	22,774

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Value of containers not included.
P Preliminary; - Nil; nes Not elsewhere specified; .. Not available; * Estimated.

TABLE 2. CANADIAN ASBESTOS PRODUCERS, 1986

Producers	Mine Location	Normal Mill Capacity ore/day	Normal Mill Capacity fibre/year	Remarks
		(tonnes)		
Baie Verte Mines Inc.	Baie Verte, Nfld.	6 600	80 000	Open-pit.
LAB Chrysotile Inc.[1]				Partnership owned 55 per cent LAQ and 45 per cent Société nationale de l'amiante (SNA).
- Lake Asbestos of Quebec, Ltd. (LAQ)	Black Lake, Que.	9 000	160 000	Open-pit. A joint venture with ASARCO Incorporated and Campbell Resources Inc.
- Asbestos Corporation Limited				(SNA) Quebec Crown corporation.
British Canadian mine	Black Lake, Que.	7 000	70 000	Open-pit.
King mine	Thetford Mines, Que.			An underground operation - closed in October.
- Bell Asbestos Mines, Ltd.	Thetford Mines, Que.	2 700	70 000	(SNA) Quebec Crown corporation. Underground.
J M Asbestos Inc.				
- Jeffrey mine	Asbestos, Que.	15 000	300 000	Open-pit (effective capacity reduced by one-half in 1982).
Carey Canada Inc.	East Broughton, Que.			Closed in April. Mainly produced groups 6 and 7 from open-pit.
Cassiar Mining Corporation	Cassiar, B.C.	5 000	100 000	Open-pit.
Total of six producers at year-end			780 000	

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[1] A partnership involving three operating companies.

TABLE 3. CANADA, ASBESTOS PRODUCTION AND EXPORTS, 1980-86

	Crude	Milled	Shorts	Total
	(tonnes)			
Production[1]				
1980	-	690 493	632 560	1 323 053
1981	10	567 288	554 547	1 121 845
1982	-	394 554	439 695	834 249
1983	-	448 953	408 551	857 504
1984	-	442 503r	394 151r	836 654
1985	-	397 729	352 461	750 190
1986p	-			640 000
Exports				
1980	-	653 358	564 379	1 217 737
1981	10	519 777	542 402	1 062 189
1982	555	454 440	425 701	880 696
1983	931	384 068	368 912	753 911
1984	167	430 391	366 206	795 853
1985	582	395 127	326 294	722 003
1986 **(Jan.-Sept.)**	127	273 228	252 234e	525 589e

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Producers' shipments.

p Preliminary; - Nil; r Revised.

TABLE 4. WORLD ASBESTOS PRODUCTION, 1985

Country	Tonnes^e
U.S.S.R.	2 400 000
Canada	750 190
Zimbabwe	174 000
Brazil	172 000
Rep. of South Africa	164 000
China	140 000
Italy	136 000
United States	57 457
Greece	47 000
Turkey	31 000
Swaziland	26 000[1]
Cyprus	12 000
Colombia	11 500
Yugoslavia	7 400
Korea	5 000
Japan	4 000
India	2 000
Taiwan	1 500
Argentina	1 200
Mozambique	800
Bulgaria	600
	4 143 647

Sources: United States Bureau of Mines and Energy, Mines and Resources Canada.

[1] Reported figure.

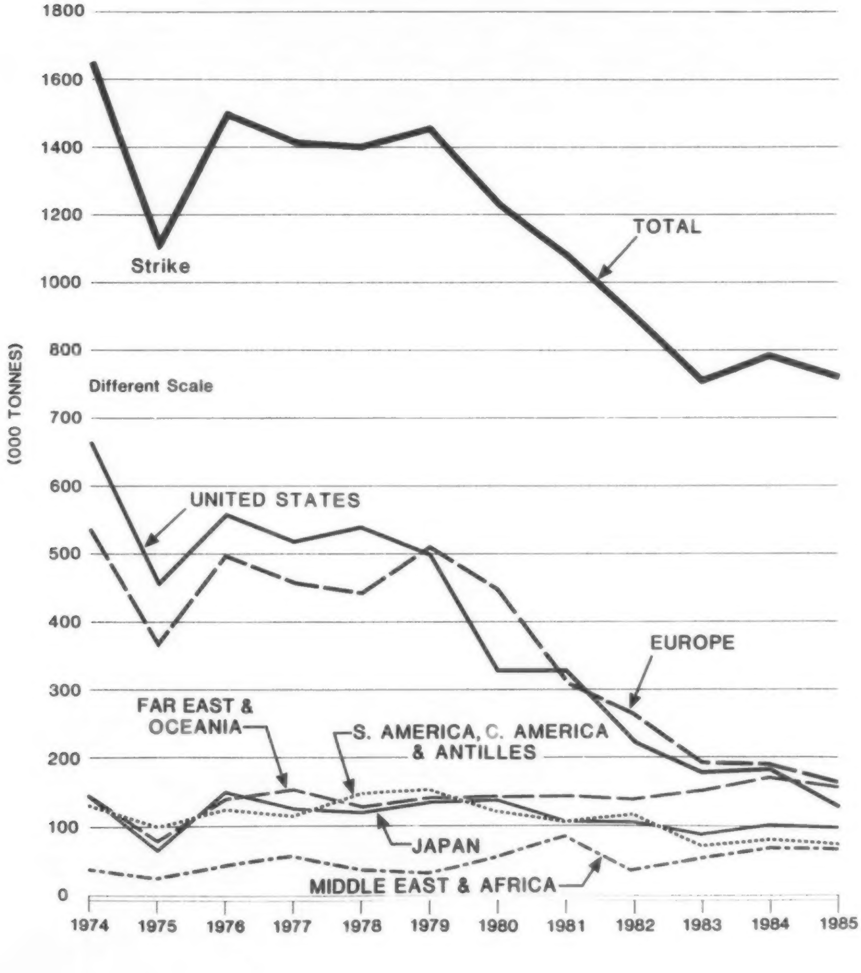
e Estimated.

TABLE 5. CANADIAN ASBESTOS CONSUMPTION, 1983-85

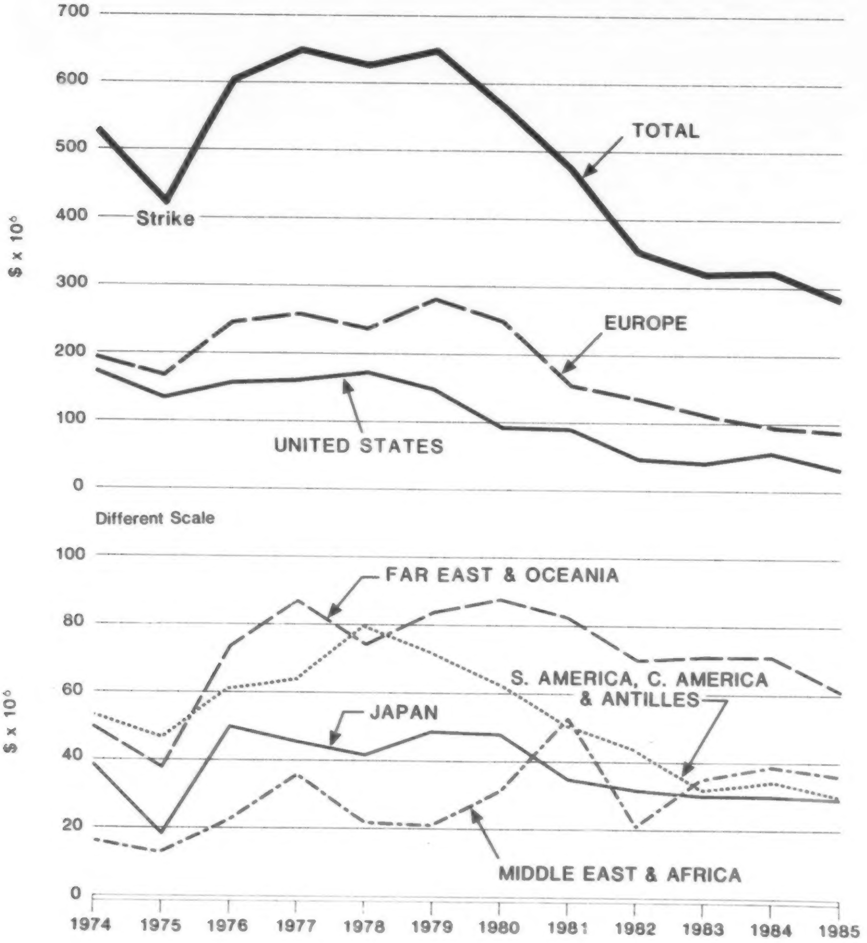
	1983r		1984		1985	
	(tonnes)	(%)	(tonnes)	(%)	(tonnes)	(%)
Paper; textiles, a/c sheet; a/c pipe; insulation; roofing	23 128	48	11 792	44	7 062	35
Flooring products, plastics; coatings and compounds	9 246	34	8 898	33	6 607	33
Friction products; packing and gaskets	4 816	18	6 123	23	6 309	32
Total	27 190	100	26 813	100	19 978	100

r Revised.

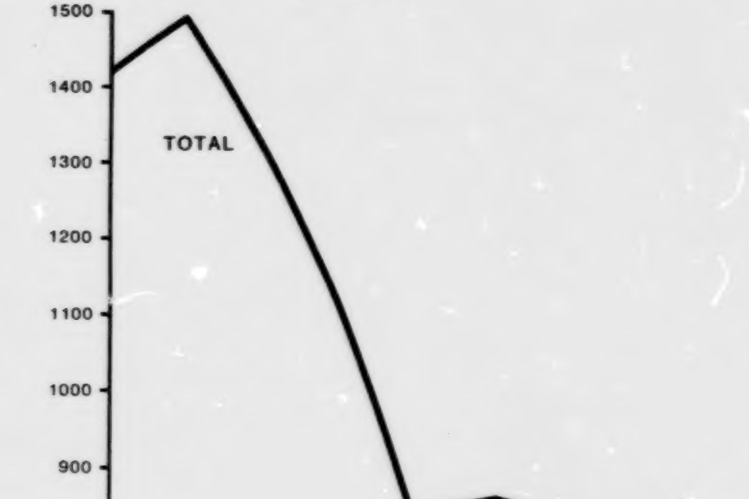
CANADIAN EXPORTS OF ASBESTOS (ALL GROUPS) BY COUNTRY OR REGION (1974-85) (TONNES)



CANADIAN EXPORTS OF ASBESTOS (ALL GROUPS) BY COUNTRY OR REGION (1974-85) (CONSTANT 1979 $)



CANADIAN ASBESTOS SHIPMENTS
1978-86



Barite and Celestite

G.O. VAGT

SUMMARY

Canadian shipments of barite in 1986 amounted to 36 888 t valued at an estimated $4.64 million. This compares to 71 049 t valued at $5.50 million shipped in 1985. Following a period of moderate recovery during the period 1982-85, shipments dropped substantially with the 50 per cent drop in crude oil prices and attendant decline in well-drilling activity as OPEC flooded world oil markets. Imports of refined barium carbonate in 1986, one of the most important barium chemicals derived from barite, amounted to an estimated 3 700 t valued at $1.3 million.

Barite ($BaSO_4$) is a valuable industrial mineral because of its high specific gravity (4.5), low abrasiveness, chemical stability and lack of magnetic and toxic effects. Its dominant use is as a weighting agent in oil and gas drilling muds required to counteract high pressures confined by the substrata.

This mineral is found in many countries of the world and is the raw material from which nearly all other barium compounds are derived. The major world producers of barite are: China, United States, India, U.S.S.R., Mexico and Morocco. In recent years, China has become very important in world trade and is the leading foreign supplier of barite to the United States.

CANADIAN DEVELOPMENTS

Barite was produced during 1986 from operations in British Columbia, Ontario and Nova Scotia.

Mountain Minerals Co. Ltd., in eastern British Columbia, closed its Parson mine operation pending improved economic conditions. Normally, crude barite is shipped to the company's grinding plant at Lethbridge, Alberta. Magcobar Minerals Division of Dresser Canada, Inc. was inactive at its British Columbia Fireside deposit near kilometre 588 of the Alaska Highway. NL Chem Canada, Inc. continued to process crude barite at its grinding plant in Onoway, Alberta.

Extender Minerals of Canada Limited mined barite near Matachewan, Ontario. Production of the high-quality dry-ground product, by open-pit mining, is used for filler and extender pigments in paints and plastics.

In Nova Scotia, Nystone Chemicals Ltd. produced pharmaceutical-grade barite from its deposit 2 km northeast of Brookfield. Diversification to supply drilling-grade barite is possible under favourable conditions.

Scotsville Mineral Resources, after starting up its Scotsville, Cape Breton property in 1984 fell into receivership in 1986.

CONSUMPTION

Consumption of barite in Canada in 1985 was 59 284 t, down from a revised 71 568 t the previous year. About 90 per cent was used for well drilling and the balance was for the manufacture of plastics, bearings, brake linings and other products.

WORLD DEVELOPMENTS

World production of barite in 1986 was an estimated 4 264 million t according to preliminary estimates by the United States Bureau of Mines. This compares to 6 078 million t in 1985 (Table 3).

China, firmly established as the world's leading producer since 1983, accounted for about 1.0 million t or 16 per cent of world output in 1985. The United States, by far the second largest producer, accounted for 0.67 million t in 1985 and imported 1.9 million t, nearly one half from China. Net import reliance, as a per cent of apparent consumption is about 66 per cent.

Many mergers were announced in the drilling-fluids business. In the United States, Dresser Industries, Inc. and its Magcobar divisions, excluding lead-mining operations, were merged with the IMCO Services Division of Halliburton Company. Both companies have worldwide barite and bentonite mining, processing and grinding interests.

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PRICES

Excess world supplies and low ocean-freight rates continued to depress published prices for all drilling-mud grade barite. Notably, low-cost crude barite from China continued to affect western world prices. Prices in the range of $US 200-400 for barite used in smaller quantities in chemical and filler/extender markets remained about the same.

United States prices of barite as reported in Engineering and Mining Journal[1], of December 1986.

	$ per short ton
Unground	
Chemical and glass grade:	
Hand picked, 95% $BaSO_4$, not over 1% Fe	90.00
Magnetic or flotation, 96-98% $BaSO_4$, not over 0.5% Fe	116.00
Imported drilling mud grade, specific gravity 4.20 - 4.30, cif Gulf ports	26.00-39.00
Ground	
Water ground, 95% $BaSO_4$ 325 mesh, 50-lb bags	70.00-165.00
Dry ground, drilling mud grade, 83-93% $BaSO_4$, 3-12% Fe, specific gravity 4.20-4.30	60.00-90.00
Imported	
Specific gravity 4.20-4.30	40.00-55.00

[1] Published by McGraw-Hill.

USES

Principal specifications for barite used in well-drilling usually require a minimum specific gravity of about 4.2, a particle size of 90-95 per cent minus 325 mesh, and a maximum of 250 ppm soluble alkaline earths, as calcium.

Barite is used in paint as a special filler or "extender pigment". This is a vital constituent that provides bulk, improves consistency of texture, surface characteristics and application properties, and controls prime pigment settling and viscosity. Specifications for barite used in the paint industry call for 95 per cent $BaSO_4$, particle size at least minus 200 mesh, and a high degree of whiteness or light reflectance. Final "wet milled" and "floated" products result in smooth micro-crystalline surfaces that prevent agglomeration, thus allowing easy dispersal in water as well as in oil-soluble binders. When barite is used in highly pigmented distemper or latex paints, a degree of light scattering is attributed to the barite, thereby allowing it to function as a pigment.

The glass industry uses barite to increase the workability of glass, to act as a flux, assist decolouration and increase the brilliance or lustre of the product. Specifications call for a minimum of 96 to 98 per cent $BaSO_4$, a particle size range of 40 to 140 mesh and usually a magnetically separated ore is used with iron often reduced to 0.1 per cent. However, producers of fine glassware use precipitated barium carbonate to circumvent impurity problems often associated with natural barite.

The specifications for natural barite used as a filler in rubber goods vary, but the main factors are whiteness and particle size range. For general filler and extender uses most manufacturers want a product that is virtually all minus 325 mesh. Colour is important to many users.

CANMET R&D

Barite samples from four deposits in Nova Scotia and one in Newfoundland were studied with a view to evaluating the available resources of mud-grade barite suitable for offshore oil- and gas-well drilling.

The Nova Scotia samples, from Scotsville, Lake Ainslie, Pine Brook and Brookfield, were investigated by dry- and wet-gravity separation methods including tables, jigs, and spiral classifiers. In addition, high intensity magnetic separation was used to evaluate the Brookfield samples which contain siderite as the main impurity. Also, recovery of barite from the Lake Ainslie and Pine Brook reject fines was further investigated by froth flotation. Results of this study, summarized in CANMET report MPP/MSL 86-95, 'A Study of the Processing of Barite Samples from Selected Deposits in Nova Scotia', demonstrated the potential for the recovery of significant quantities of drilling-grade barite from each of the noted four deposits. Fundamentally however grade and recovery of final products is very dependent on the effective 'freeing' of contained impurities prior to gravity and/or magnetic separation and the treatment of reject fines by flotation.

Recovery of barite contained in the tailings sample from the Buchans, Newfoundland lead-zinc mine and mill was investigated by gravity separation using both a 'pinched sluice' and a spiral classifier. The objective was preconcentration producing an upgraded feed for subsequent treatment by flotation. Unpublished results indicate a significant upgrading of the contained barite by removal of the plus 100 mesh, low-grade fraction followed by spiral treatment of the minus 100 mesh fines. Results of the pinched sluice test were inconclusive.

Completion of a summary report on barite, celestite and fluorite deposits in Canada is scheduled for 1987. This report will reference major Canadian occurrences and briefly summarize related past and present research and development.

Mineral Development Agreements

Federally-funded MDA studies related to barite include:

- Nova Scotia Barite, DSS File No. 07SQ.23440-5-9059
- Pine Brook, Cape Breton, Barite, DSS File No. ST38.23440-6-9083

For further information on R & D relating to barite, the contact at CANMET is R.K. Collings, 613-995-4029.

OUTLOOK

The demand for barite in 1987 is expected to increase based on confidence generated by the year-end announcement that the leading OPEC countries agreed to reduce oil production for the first-half of 1987 and to return to fixed export prices. In 1986, only about 6,300 wells or 7.9 million m were drilled in Canada according to preliminary statistics, whereas in 1985 about 11,700 wells or 12.9 million m were drilled. Clearly, well-drilling activity will be based on expectations for higher prices in addition to the optimism arising from changed regulatory and tax regimes at both federal and provincial levels of government.

With more delineation drilling needed to confirm reserves offshore, additional supplies of barite will be required. There is potential for discovery and development of barite deposits in most regions, however sources from abroad will likely continue to compete with domestic producers as long as excess world capacity and low ocean-freight rates prevail.

CELESTITE (STRONTIUM)

SUMMARY

There has been no Canadian production of celestite ($SrSO_4$) since Kaiser Celestite Mining Limited, a subsidiary of Kaiser Aluminum & Chemical Canada Investment Limited, closed its mining operation at Loch Lomond, Nova Scotia and its strontium products plant at Point Edward, Nova Scotia, in 1976. Timminco Limited, the new owner of the McCrae deposit at Enon, Cape Breton County, carried out some exploration and bulk sampling for analytical and metallurgical tests. Also, at Beckwith in Cumberland County, the company did some drilling and bulk sampling. Overall plans are to prove up sufficient reserves to justify a mine to supply raw material to the company's plant in Haley, Ontario. Timminco, the only producer of strontium metal in North America, plans to increase production of both strontium and magnesium at its Haley plant. Supplies of strontium carbonate, the necessary intermediate compound derived from celestite, are presently imported from Europe.

NORTH AMERICAN SCENE

North American consumers continue to depend totally on imports of strontium minerals. The strontium mining industry in the United States has been dormant since 1959, and Mexico and West Germany are the major suppliers of celestite and strontium compounds to the U.S. market.

In the United States, imports of strontium minerals and strontium compounds for consumption in 1986 were an estimated 16 500 t and 3 000 t, respectively.

USES

Celestite is used to produce commercial strontium compounds, principally strontium carbonate and strontium nitrate. Strontium carbonate is primarily used in glass faceplates for colour television picture tubes where it improves the absorption of X-rays emitted by the high voltage tubes. Other uses include pyro-technics and signals, and ferrite ceramic permanent magnets used in small electric motors. In the sulphate form strontium is used for purifying electrolytic zinc.

Mineral Development Agreements

A federally-funded MDA study related to celestite is:

- Nova Scotia Celestite, DSS File No. 03SQ.23440-6-9031.

For further information on R&D relating to strontium, the contact at CANMET is R.K. Collings, 613-995-4029.

PRICES

United States prices of celestite according to Chemical Marketing Reporter, December 19, 1986

	$ per short ton
Strontium carbonate glass grade, bags, truckload, works	745.00
	$ per 100 pounds
Strontium nitrate, bags, carlot, works	51.50

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
CANADA					
49205-1	Drilling mud and additives	free	free	free	free
68300-1	Barytes	free	10	25	free
92818-1	Barium oxide, hydroxide peroxide	1.9	1.9	25	1
92842-1	Barium carbonate	10	12.8	25	8.5
93207-5	Lithopone	free	10.8	25	free
MFN REDUCTIONS UNDER GATT (effective January 1 of year given)			1986	1987	
92818-1			1.9	free	
92842-1			12.8	12.5	
93207-5			10.8	10.5	
UNITED STATES (MFN)					
	Barium carbonate:				
472.02	Natural, crude (witherite)		free		
472.06	Precipitated		0.4¢ per pound		
	Barium sulfate:				
472.10	Natural, crude (barytes)		$1.27 per ton		
472.12	Natural, ground (barytes)		$3.25 per ton		
472.14	Precipitated (blanc fixe)		0.2¢ per pound		
473.72	Lithopone		2.3		
473.74	Lithopone		4.0		
472.04	Barium carbonate, natural ground (witherite)		4.4	4.2	

Sources: The Customs Tariff, 1986, Revenue Canada, Customs and Excise. Tariff Schedules of the United States Annotated 1986, USITC Publication 1776. U.S. Federal Register Vol. 44, No. 241.

TABLE 1. CANADA, BARITE PRODUCTION AND TRADE, 1984-86 AND CONSUMPTION, 1983-85

	1984		1985		1986P	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Production (mine shipments)	64 197	6,974	71 049	5,503	36 888	4,635
					(Jan.-Sept.)	
Imports						
United States	6 485	645	7 033	820	8 418	834
Ireland	-	-	8 011	381	-	-
Netherlands	609	167	489	170	450	170
Morocco	10 594	890	11 020	808	-	-
Other	-	-	34	13	7	1
Total	17 688	1,702	26 587	2,192	8 875	1,005
Exports						
West Germany	-	-	-	-	..	1
United States	1 248	314	1 679	479	4 005	758
Total	1 248	314	1 679	479	4 005	759
	1983		1984		1985P	
Consumption[1]						
Well drilling[e]	60 000		64 000		51 000	
Paint and varnish	1 484		1 449		1 526	
Other[2]	4 200		6 119		6 758	
Total[e]	65 684		71 568		59 284	

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Available data reported by consumers with estimates by Energy, Mines and Resources Canada. Does not include inventory adjustments. [2] Other includes plastics, bearings and brake linings, foundries, chemicals, explosives, glass and glass products, etc.
P Preliminary; [e] Estimated; - Nil; .. Not available.

TABLE 2. CANADA, BARITE PRODUCTION TRADE AND CONSUMPTION, 1975, AND 1980-86

	Production[1]	Imports	Exports	Consumption[e]
	($)		(tonnes)	
1975	2,305,819	4 479	45 606	40 229
1980	4,380,000	45 157	645	138 829
1981	5,124,000	16 278	405	94 027
1982	2,359,000	23 457	482	25 477
1983	4,869,000	29 952	795	65 684
1984	6,974,000	17 688	1 248	71 568
1985	5,503,000	26 587	1 679	59 284P
1986P	4,635,000			..
1986P (9 months)		8 875	4 005	..

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Mine shipments.
P Preliminary; [e] Estimated; .. Not available.

TABLE 3. WORLD BARITE PRODUCTION, 1985

Country	Tonnes
China[e]	998
United States	670
India	608
U.S.S.R.[e]	540
Mexico	490
Morocco	425
Ireland	220
Thailand	172
Germany, Federal Republic of	170
Peru	163
France	150
Italy	100
Canada	71
Yugoslavia	36
Other Market Economy Countries	1 017
Other Centrally Planned Economies[e]	248
	6 078

Sources: United States Bureau of Mines and Energy, Mines and Resources Canada.
[e] Estimated.

Bentonite

G.O. VAGT

Three companies presently mine and process bentonite in Canada. Statistics on production and exports are not published for reasons of confidentiality. Imports have traditionally served almost the entire needs of the iron ore pelletizing industry and much of the requirements of other sectors. Relatively small quantities of activated bentonite from Manitoba are exported to the United States.

Bentonite consumption, mainly centered in Quebec and Ontario, grew substantially in the 1970s, largely with increased use as a binder for pelletizing iron ore concentrates. However, the first half of the 1980s witnessed an overall decline in consumption as the Canadian iron ore industry suffered from reduced demand.

Bentonite-related terminology is not standardized internationally and may be confusing, particularly when trade is involved. Basically, bentonite is a clay of varied chemical composition consisting primarily of the mineral montmorillonite a member of the smectite group of clay minerals. "Smectite", as a group name, replaces confusing terminology that includes "montmorillonite" as both mineral species and group names.

Bentonite may originate from smectitic clays formed from volcanic ash, tuff or glass, other igneous rocks, or from rocks of sedimentary or uncertain origin. The deposits occur in relatively flat-lying beds having various chemical compositions and mineral impurities. Natural clay may be creamy white, grey, blue, green or brown; and, in places, beds of distinctly different colour are adjacent. Fresh moist surfaces are waxy in appearance; on drying, the colour lightens, and the clay has a distinctive cracked or crumbly texture.

Montmorillonite is a hydrated aluminum silicate with weakly-attached cations of sodium and calcium which impart different properties to bentonite depending on amounts and proportions present. One method of classifying bentonite is based on its swelling capacity when wet. With sodium as the dominant or abundant exchangeable ion, swelling of about 10 times the original dry volume will occur, and when added to water, gel-like masses result. Sodium bentonite also possesses a high dry-bonding strength, especially at high temperatures, a feature important in the pelletizing of iron ores and in the manufacture of some ceramic products.

Montmorillonite clays have ion-exchange properties and, by adsorption, absorption and chemical activity, bentonite can collect many types of inorganic and organic compounds, sometimes selectively. In general, the non-swelling or calcium bentonites exhibit the more pronounced adsorptive characteristics. While naturally-occurring clays may exhibit adsorptive or bleaching properties, their efficiencies are commonly improved by acid leaching or, as the process is generally termed, activation.

Another clay, "fuller's earth", also contains mainly smectic-group clay minerals and is very similar to non-swelling bentonite. These clays are non-plastic, usually high in magnesia and have natural bleaching and absorbent properties allowing their use for decolourizing and purifying.

CANADIAN INDUSTRY AND DEVELOPMENTS

Known Canadian bentonite occurrences are confined to Cretaceous and Tertiary rocks at many localities in Manitoba, Saskatchewan, Alberta and British Columbia. Although clay beds occur in rocks older than Cretaceous in Canada, none of these have been identified as bentonite.

Pembina Mountain Clays Incorporated mines non-swelling bentonite from the Upper Cretaceous Vermillion River Formation, 30 km northwest of Morden, Manitoba, which is 130 km southwest of Winnipeg. Some bentonite is dried and pulverized in a plant

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at Morden, but the bulk of production is railed from Morden to the company's activation plant at Winnipeg, where it is leached, washed, filtered, dried, pulverized and bagged. The main use is for decolourizing and purifying mineral and vegetable oils, animal fats and tallows. Highly sorptive properties also make this bentonite suitable for pet litters and floor sweeping compounds.

In Saskatchewan, Avonlea Mineral Industries Ltd. operates a processing plant in Wilcox, approximately 30 km south of Regina. Raw material is transported a distance of approximately 20 km to the 60 000 tpy plant. Major uses of the final product are for well-drilling muds by the oil industry, as a binder in foundry sands, for civil engineering applications such as reservoir sealing, and for pelletizing animal feeds.

In Alberta, Dresser Minerals Division of Dresser Industries, Inc. recovers swelling bentonite from the Edmonton Formation of Upper Cretaceous age. The deposits are in the Battle River Valley, 14 km south of Rosalind, the site of the company's processing plant. The bentonite is mined selectively from relatively shallow paddocks or pits in the dry summer months. Some natural drying may be done by spreading and harrowing material before trucking it to the plant for drying, pulverizing and bagging. This bentonite, of intermediate swelling quality, may be used as a foundry clay, as a sealer for farm reservoirs, as feed pelletizing material, as a drilling-mud additive, as an additive to water for fire fighting and as a soil stabilizer.

USES, CONSUMPTION AND TRADE

Bentonite, in addition to having many uses by itself also serves as a minor constituent to impart favourable characteristics to many products. Major industrial uses are widely distributed geographically with iron ore pelletizing located in Quebec and Ontario, foundries mainly in Ontario and well drilling mainly in western Canada.

Select swelling bentonite, used as a binder in the pelletizing of iron ore concentrates, currently accounts for about 54 per cent of the reported total consumption of bentonite in Canada. About 8 kg is used in every tonne of concentrate to provide pellets with sufficient "green" strength to withstand handling during the drying and firing stages. Quantities required vary with the mineralogy and particle size of the concentrate.

Consumption of bentonite in the oil- and gas-well drilling industry is subject to considerable fluctuation not necessarily directly related to the footage drilled. Influencing factors include the type of formation being drilled, geographic location and hole depth.

The required muds contain about 10 per cent swelling bentonite, which is used principally to prevent the loss of drilling fluid into permeable zones by forming a mud cake on the wall of the drill hole. Of equal importance, swelling bentonite acts as a suspension agent to carry drill cuttings in water-based muds to the surface. Synthetic bentonite (sodium-exchanged calcium bentonites) may also be used in special muds, depending upon the cost and availability of natural swelling bentonites. Bentonite used in well drilling currently represents about 22 per cent of Canadian consumption.

Swelling bentonite also serves as a binder in moulding sands used in iron and steel foundries. This application accounts for approximately 21 per cent of total Canadian bentonite consumption. Similarly, this type of bentonite serves as a binder in stock feeds. Small quantities are used as a plasticizer in abrasive and ceramic mixes and as a filler in paints, paper, rubber, pesticides, cosmetics, medicinal products, and cleaning and polishing compounds. Engineering applications are: in grout for sealing subsurface water-bearing zones, dams and reservoirs; as additives to cements, mortars and concretes to suppress bleeding of the mixing water; as a compacting agent for gravels and soils; and as a ground stabilizing medium for excavations when used in a bentonite-water suspension. Bentonite slurry is also effective in fighting forest fires.

Some non-swelling bentonite is used in pelletizing stock feed, as a carrier and diluent for pesticides, and as a cleaning powder for animals.

Activated bentonite is used in decolourizing mineral and vegetable oils, animal fats, waxes, beverages and syrups. It is also used in some countries as a catalyst in the refining of fluid hydrocarbons.

Bentonite production in the United States was an estimated 2.5 million t in 1986 compared to 2.9 million t in 1985. Deposits in Wyoming and Montana account for more than 80 per cent of total United States production. In Wyoming, the Cretaceous Fort Benton Formation has traditionally provided the world's most outstanding swelling bentonite along with the customary specifications and standards. Although there are numerous occurrences of bentonite in many countries, it is mined in only a few. Canada is by far the main importer from the United States, which also ships some bentonite throughout the world. The distribution of United States consumption contrasts significantly with that of Canada. Estimates of bentonite uses in the United States reveals drilling mud accounts for 40 per cent of market demand, foundry sand bond accounts for 21 per cent, while iron ore pelletizing accounts for 14 per cent.

A variety of fuller's earth, mainly comprising attapulgite, a lath-shaped clay mineral, was produced primarily in Florida and Georgia. Additional types of fuller's earth, mainly comprising montmorillonite, were produced in seven other states.

RESEARCH AND DEVELOPMENT

As part of a five-year review program on industrial minerals and related research, CANMET completed a review of past research on domestic deposits of bentonite and updated files on occurrences and current industry activity. Equipment has been assembled to assist in the further characterization of domestic bentonites.

There is potential for increasing the current use of bentonite in waste management relating to controlling seepage into groundwater. One particular field of future interest involves the use of certain types of bentonite, along with other materials, as backfill and buffer material for sealing cavities that may eventually be used to contain nuclear wastes.

For further information on bentonite R&D at CANMET, contacts are:
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(613) 992-8794.

OUTLOOK

Demand for well-drilling grade bentonite has been very volatile in the past, however it is expected that this use will account for most of the increase in North American bentonite consumption, forecast between 2 and 4 per cent to 1990. Experts consider that some of the new mud systems using polymers will reduce bentonite consumption but the typical well will be drilled using conventional mud systems.

Demand for pelletizing grade bentonite is expected to remain flat. Over the first half of this decade Canadian iron ore producers closed two pelletizing operations and expanded one. Existing pelletizing capacity now is expected to meet demand for the rest of the decade. Transportation costs to distant pelletizing plants often add considerably to the cost of natural swelling Wyoming bentonite. For this reason, Quebec-based iron ore producers have imported increasingly from offshore sources, primarily Greece.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
CANADA					
29500-1	Clays, not further manufactured than ground	free	free	free	free
93803-2	Activated clay	10	12.8	25	8.5
20600-1	Fuller's earth, in bulk	free	free	free	-
MFN Reductions under GATT (effective January 1 of year given)			1986	1987	
			(%)		
93803-2	Activated clay		12.8	12.5	
UNITED STATES (MFN)			(cents per long ton)		
521.61	Bentonite		40	40	
521.51	Fuller's earth - not beneficiated		25	25	
521.54	Fuller's earth, bulk		50	50	
			(cents per lb + % ad valorem)		
521.87	Clays, artificially activated, etc.		0.01 2.9%	- 2.5%	

Sources: The Customs Tariff, 1986, Revenue Canada; Customs and Excise. Tariff Schedules of the United States Annotated (1986), USITC Publication 1775. U.S. Federal Register, Vol. 44, No. 241.

PRICES

United States bentonite prices according to **Chemical Marketing Reporter**, December 29, 1986

	$
Bentonite, domestic, bulk, carlots, fob mines West Coast, per short ton	43.50

TABLE 1. CANADA, BENTONITE IMPORTS[1] AND CONSUMPTION[2], 1970, and 1975-86

	Imports		Consumption
	(tonnes)	($000)	(tonnes)
1970	351 066	5,590	285 671
1975	287 886	9,388	286 109
1976	367 162	10,244	335 553
1977	481 213	13,757	346 698
1978	367 931	14,893	264 894
1979	655 043	29,571	345 083
1980	490 714	27,982	248 585
1981	326 456	22,088	286 359
1982	252 481	22,100	182 266
1983	199 967	19,924	197 429
1984	353 784	25,942	265 289
1985	363 995	31,950	285 979
1986[3]	228 983	20,160	..

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Includes bentonite, fuller's earth and activated clays and earths. [2] Includes only bentonite and fuller's earth. [3] First 9 months of 1986 only.

.. Not available.

TABLE 2. CANADA, BENTONITE IMPORTS 1982-86[1] AND CONSUMPTION, 1982-85

	1982		1983		1984		1985		Jan.-Sept. 1986	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Imports										
Bentonite										
United States	160 050	7,991	109 720	5,213	243 746	10,050	280 942	14,304	143 771	7,075
Greece	77 981	4,320	77 472	4,318	93 194	5,226	64 901	3,707	71 602	3,903
West Germany	-	-	36	14	91	29	177	85	21	3
Other	-	-	-	-	23	2	-	-	5	..
United Kingdom	-	-	-	-	-	-	72	13	-	-
Total	238 031	12,311	187 228	9,545	337 054	15,307	346 092	18,109	215 399	10,981
Activated clays and earths										
United States	10 700	7,529	9 319	7,691	10 180	8,047	10 728	11,354	7 592	7,130
France	2 500	2,325	2 574	2,306	2 398	2,062	1 703	1,554	1 626	1,447
West Germany	168	129	256	248	1	1	506	370	497	265
Greece	1	1	-	-	-	-	-	-	-	-
Italy	-	-	21	33	-	-	-	-	-	-
Guyana	-	-	14	17	-	-	-	-	-	-
United Kingdom	-	-	19	7	-	-	1	2	2	13
Total	13 369	9,714	12 203	10,304	12 579	10,110	12 938	13,280	9 717	8,855
Fuller's earth										
United States	1 081	75	536	75	4 151	525	4 965	561	3 867	324

Consumption[2] (available data)	1982	1983	1984	1985P
	(tonnes)			
Pelletizing iron ore	127 737r	112 181	148 328	155 494
Well drilling	21 860	34 917	46 472	63 918
Foundries	29 042	46 173	63 709	59 201
Fertilizer stock and poultry feed	158	221	2 420	2 657
Paint and varnish	556	533	621	910
Other products[3]	2 913	3 404	3 739	3 799
Total	182 266	197 429	265 289	285 979

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Figures for 1986 include first nine months only. [2] Does not include activated clays and earths or fuller's earth. [3] Refractory brick mixes, cements, heavy clay products, rubber products, chemicals, paper products and other miscellaneous minor uses.

- Nil; P Preliminary; r Revised; .. Not available.

Beryllium

G. BOKOVAY

Beryllium is a gray, corrosion-resistant metal with a specific gravity of 1.85, which is between that of aluminum and magnesium. The metal has a tensile strength considerably greater than either of these two metals, a high melting point (1290°C), fatigue resistance characteristics at high temperatures, good electrical and thermal conductivity and unique nuclear moderating and reflecting properties.

Beryllium is used in a variety of military and industrial applications in metal, alloy and oxide forms, despite its relatively high price. In recent years, the largest and fast growing market has been in the electrical and electronic sectors where it is used as an alloying agent for copper. However, after recording phenomenal growth in 1984, demand fell in 1985 in response to a downturn in the electronics industry. While it was reported that beryllium consumption recovered somewhat in 1986, the level of demand was expected to remain below that recorded in 1984.

With forecast increases in both the number and size of markets for beryllium products, particularly in the high-tech field, the outlook for this commodity is extremely positive. However, this optimism must be tempered by the fact that the beryllium industry is extremely small and will remain relatively so. Moreover, growth is expected to be somewhat erratic as a result of rapidly changing technology and the variable nature of defence programmes.

Canada does not produce beryllium or beryllium minerals, but this could change in the next decade in view of a large high grade deposit which has been identified at Thor Lake in the Northwest Territories. The United States, the largest consuming nation, has significant beryllium reserves. However, ownership changes affecting a large share of the U.S. fabricating sector, concern over the quality and ease of extraction of U.S. beryllium deposits, and apparent desire of U.S. authorities to conserve a so-called strategic material, favour a Canadian development in the next decade.

PRODUCTION OF BERYLLIUM MINERALS

Beryllium is produced commercially from two minerals, beryl and bertrandite. Beryl ($3BeO.Al_2O_3.6SiO_2$), which occurs in pegmatite dykes, is hand-picked and cobbed to remove gangue minerals adhering to the beryl crystals. The separation of beryl by mechanical or flotation techniques is difficult because the densities of beryl and associated minerals are similar. Since beryl production is labour intensive, beryl is principally mined in developing countries. Brazil is the largest producer in the western world.

Beryl has been mined in Canada although there has been no production in recent years.

Bertrandite ($Be_4\ Si_2\ O_7\ (OH)_2$), which has been mined in the United States since 1969 by Brush Wellman Inc., has become the most important source of beryllium metal in the western world. The company operates an open-pit bertrandite mine in the volcanic tuff beds of the Topaz - Spor Mountain area of western Utah.

World reserves of beryllium minerals are very large in relation to current rates of extraction. At the end of 1985, Brush Wellman estimated its ore reserves at 5.12 million t grading 0.64 per cent beryllium oxide (BeO). World reserves outside China have been estimated by the U.S. Bureau of Mines at 382 000 t of contained beryllium.

CANADIAN DEVELOPMENTS

The Thor Lake deposit of Highwood Resources Ltd. in the Northwest Territories, which was first staked in 1970 as a potential source of uranium, is considered to be one

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of the most promising beryllium prospects in the western world. To date, exploratory drilling has identified at least 1.63 million t grading 0.85 per cent BeO within the so-called north section of the T zone containing 400 000 t grading 1.4 per cent BeO. The company has reported that the deposit is amendable to open-pit mining. Unlike other known beryllium deposits, Thor Lake is somewhat unique in that beryllium is contained with the mineral phenacite ($Be_2 Si O_4$). However, initial test work has achieved encouraging results in terms of concentrate grade and mineral recovery. In addition to beryllium, the Thor Lake deposit also contains significant amounts of yttrium, rare earths, niobium, gallium and zirconium.

During 1986, Highwood and Hecla Mining Company of Canada Ltd., a subsidiary of Hecla Mining Company of the United States, signed a definitive agreement to enter into a joint venture for commercial development of the Thor Lake deposit. Under the terms of the agreement, Hecla will, in return for a 50 per cent interest in the property, reimburse Highwood for half of the $8 million already spent on the site by that company as well as provide financing for mine development and downstream facilities. The cost of such development has been estimated at $US 30 million.

As a first step, Hecla plans to complete a feasibility and marketing study for the project within eighteen months, with full-scale pilot plant metallurgical testing expected to begin in March or April of 1987. Assuming favourable results, the Thor Lake mine could begin commercial production in 1988.

There have been no recent indications as to the size of the mining operation which is envisaged, although it was reported during 1985 that Highwood was considering a production target of about 450 tpy of beryllium concentrate grading 14 per cent BeO, with recovery of yttrium. It has been reported, however, that the joint venture will examine the feasibility of producing beryllium hydroxide. At the present time, Brush Wellman Inc. of the United States is the only fully integrated beryllium producer in the western world and the only firm with primary processing facilities.

While the Thor Lake deposit is the most advanced and most promising beryllium prospect in Canada, a number of other occurences have attracted significant interest in recent years. These include the Hellroaring Creek deposit of Bearcat Explorations Ltd. in British Columbia, the York County, New Brunswick prospect of Shediac Bay Resources Inc. and the Strange Lake deposit of the Iron Ore Company of Canada (IOC) on the Quebec/Labrador border.

WORLD PRODUCTION AND DEVELOPMENTS

The United States, the U.S.S.R. and the People's Republic of China are the only fully integrated beryllium producers in the world. Production data for the United States are withheld to conform with confidentiality regulations, since Brush Wellman Inc. is the sole primary producer.

Brush Wellman produces beryllium hydroxide at a plant in Delta, Utah from bertrandite concentrate from the company's nearby open-pit mines and from imported beryl ore. The output of the Delta plant is converted to metallic beryllium, beryllium alloys and beryllia ceramics at other plants.

At Delta, a new beryl furnace designed to handle lower grade beryl ore (7 per cent BeO) was brought on stream in 1984. However, it is reported that technical problems continue to plague this circuit.

During 1985, Brush undertook a development program at its bertrandite mine to create two new open pits. The $US 10 million project was expected to be completed during 1986.

In addition to the processing of beryllium ore for its own account, Brush has also processed ore on a toll basis for Cabot Corporation, a large U.S. producer of beryllium-copper alloys. Although Cabot sold its beryllium division to NGK Insulators Ltd. of Japan (also a beryllium fabricator) in September 1986, it is expected that the tolling arrangement will remain in place. As the second largest consumer, after Brush Wellman, of beryllium hydroxide, the basic intermediate material required for downstream products, there is strong speculation that NGK may be interested in developing its own source of supply or alternatively securing supplies from an independent third party such as the Highwood/Hecla joint venture in Canada.

The list of alternatives also includes several U.S. prospects. During 1986, Cyprus Minerals Company signed a letter of intent with Cabot Corporation to form a joint venture to develop the latter's Sierra Blanca deposit in Texas. To date, exploration on the site has outlined reserves of more than 11 000 t of BeO with an ore grade of over 2 per cent. A feasibility study and mine development work have been scheduled for the next two years. Also during 1986, Emery Inc. and Cominco American Incorporated, a unit of Cominco Ltd., announced that they had signed a letter of intent concerning the mining and milling of beryllium from Emery's, Juab County, Utah bertrandite deposit. A feasibility study including a market study, metallurgical testing and further drilling is planned.

It has been reported that the People's Republic of China is planning to build a new beryllium oxide plant in the Zinjiang Uygur autonomous region. China is believed to have one of the largest reserves of beryllium in the world.

USES

Although beryllium metal and its intermediates are relatively expensive, its unique properties have found application in a wide range of goods, although in small quantities. The consumption of beryllium in the United States in 1983 was estimated at 40 per cent for nuclear reactors and aerospace applications, 36 per cent for electrical equipment, 17 per cent for electronic equipment and 7 per cent for miscellaneous uses. It is estimated that 65 per cent of the beryllium is consumed in beryllium alloys, principally beryllium-copper, 20 per cent as beryllium metal, and 15 per cent as beryllium oxide.

Beryllium-copper alloys, which account for a major portion of the total beryllium consumption, may contain anywhere from 0.3 to 2.0 per cent beryllium. In general, beryllium-copper alloys are much stronger and harder than pure copper, and still have good electrical conductivity. In addition these alloys have good corrosion resistance and low magnetic susceptibility. Beryllium-copper alloys are produced in a variety of shapes including bars, casting ingots, extrusions, plate, rod, strip, tube and wire.

Applications of Be-Cu alloys include: precision mechanical and electro mechanical springs; electrical/ electronic connectors, sockets, contacts, relays, and switches; diaphrams; dies; injection molds for plastics; non-sparking tools; undersea cable housings; bushings; welding tips; and certain applications in oil and gas drilling housings, measurement systems and drill string components. In the United States, Be-Cu master alloys and products are produced by Brush Wellman Inc. and NGK Metals Corp.

Beryllium-nickel alloys have many of the same properties as Be-Cu alloys except that they can be used in higher temperature applications for miniature electronic connector components, springs and mechanical fasteners. Other uses include surgical instruments and equipment for the glass industry.

When beryllium is added to aluminum or magnesium, the resultant alloys are more easily fabricated than the host metals and have improved oxidation resistance. It has been reported that Lockheed Missiles & Space Co., Inc. is currently working on the development of ultra low density aluminum alloys that utilize lithium and beryllium. These alloys have densities about 20 per cent lower than current aluminum alloys, with 40 to 60 per cent greater stiffness and comparable strength.

Beryllium has also been identified as a potentially useful additive to high-tensile stainless steels although current production is thought to be limited.

For products made of beryllium metal, powder metallurgy is the preferred method of fabrication since coarse crystals develop when the metal is cast. Use of this expensive metal is justified by its superior strength and stiffness relative to density in structural aerospace applications, inertial guidance system components, space-borne optics and aircraft brakes.

At the end of 1986, Brush Wellman announced a new process called "near-net-shape" which promises to significantly reduce the cost of beryllium parts. Whereas conventional parts are machined to shape from blocks, the new process produces parts that require only nominal machining. In addition, the process also improves the strength of the final product.

Beryllium metal's high moderating ratio and high neutron reflection properties have led to its use in nuclear applications despite embrittlement after long exposure to radiation.

Beryllium oxide ceramics have excellent insulating properties, high thermal conductivity and thermal shock resistance. The principal applications for this material are as components in electrical packages and substrates for high performance computers, ion lasers, defence electronics, microwave systems, telecommunications and automobile electronics.

The inhalation of small concentrations of beryllium dust or fumes has been recognized as the cause of berylliosis, a serious chronic lung disorder. However, it appears that health risks can be minimized by stringent operating procedures and proper environmental control equipment. As far as can be determined, there are no health problems associated with naturally occuring beryllium minerals.

U.S. STOCKPILE

Beryllium is of strategic importance and the U.S. General Services Administration (GSA) maintains the metal in its National Defence Stockpile. The U.S. Bureau of Mines reported that as of September 30, 1985, the stockpile held 268 t of beryllium-copper master alloy and 254 t of beryllium metal, with another 10 t expected to be added before the end of 1985. During 1986, it was reported that the GSA was considering additional purchases.

OUTLOOK

Despite relatively depressed market conditions for beryllium during 1985 and for part of 1986, the long-term outlook for the industry is very promising. Although miniaturization in the electronics industry can be expected to continue, overall growth in this sector will more than compensate. Beryllium demand should also be buoyed by further U.S. Government purchases for its defence stockpile as well as increased defence spending. In this regard, the so-called "Strategic Defence Initiative/Starwars" project is expected to be a major consumer of beryllium, particularly for laser weaponry and electronic applications.

Overall, demand for beryllium in all forms is expected to grow at between 4 and 5 per cent annually in the next decade.

With one of the most promising beryllium deposits in the western world, Canada could become a major player in the world industry either as a source of beryllium minerals for the established beryllium industry in the United States or potentially as a producer of intermediate beryllium products.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
CANADA					
34907-1	Copper beryllium alloys	4.1	4.1	25	free
35101-1	Beryllium metal	free	4.1	25	free
MFN Reductions under GATT (effective January 1 of year given)			1986	1987	
			(%)		
34907-1			4.1	4.0	
35101-1			4.1	4.0	
UNITED STATES (MFN)					
417.90	Beryllium oxide or carbonate		3.7%		
601.09	Beryllium ore		free		
628.05	Unwrought beryllium, waste and scrap		8.5%		
628.10	Beryllium, wrought		9.0%		
			1986	1987	
			(%)		
612.20	Beryllium copper master alloy		6.6	6.0	
417.92	Other beryllium compounds		3.9	3.7	

Sources: The Customs Tariff, 1986 Revenue Canada, Customs & Excise; Tariff Schedules of the United States Annotated (1986), USITC Publication 1775; U.S. Federal Register, Vol. 44, No. 241.

TABLE 1. ESTIMATED WORLD BERYLLIUM PRODUCTION[1]

	1981	1982	1983	1984	1985
	(tonnes)				
United States					
from Bertradite[2]	144.4	105.8	135.0	118.5	111.1
from Imported beryl[3]	50.7	62.5	59.1	31.2	38.9
Total	195.1	168.3	186.9	149.7	150.0
U.S.S.R.[3]	47.1	47.1	49.5	49.5	49.5
Total[4]	242.2	215.4	236.4	199.2	199.5

[1] Includes the beryllium metal equivalent of beryllium alloys and oxide. [2] Beryllium content of concentrate produced as reported by Brush Wellman Inc. - 65 per cent recovery is assumed. [3] Reported by USBM, 1985 Beryllium preprint - 65 per cent recovery assumed. [4] Excluding People's Republic of China.

TABLE 2. PRICES ($US)

Beryl ore; cif Atlantic - Ports 10% to 12% per Stu. (Eff. 19/4/82)	$90.00 - $130.00
Beryllium oxide	
Uox powder GCR, GCHG (Brush Wellman) (Eff. 2/1/85)	$55.70/lb.
Beryllium containing alloys (4% BeCu)	
275 C BeCu casting alloy (1/9/86)	$5.70-$6.75/lb.
165 C BeCu casting alloy (1/9/86)	$5.40/lb.
245 BeCu casting alloy (1/9/86)	$5.45-$6.15/lb.
10C BeCu casting alloy (30/06/86)	$5.10-5.40/lb.
(Containing less than 0.5 per cent Mg)	
Per lb. contained beryllium (1/9/86)	$152.00
Beryllium 97%	
Powder blend (200 grade), per pound	
5 000 lb. lots (Eff. 10/1/85)	$196.00
Vac. cast ingots (Eff. 10/1/85)	$225.00
f.o.b. Elmore, Ohio	
Beryllium aluminum (30/6/86)	
f.o.b. Reading, Pa., Detroit and Elmore, Ohio (100,000 lb.)/lb.	$248.00
Beryllium copper (1/9/86)	
Strip (No. 25)/lb.	$7.65
Rod, bar and wire (No. 25)/lb.	$8.10
Beryllium copper master alloy	
f.o.b. Reading, Pa., Detroit, Michigan, Elmore, Ohio, per lb. contained beryllium for 5 lb. ingot (Eff. 1/9/86)	$152.00

+ Beryllium copper alloys reflect a $1 per pound base copper price. Prices fluctuate weekly based on a predetermined copper composite price chosen by the individual companies.

Source: American Metal Market.

Bismuth

J. BIGAUSKAS

INTRODUCTION

Bismuth is generally produced as a byproduct of certain lead, copper, tin, tungsten, silver and gold ores. The important bismuth-bearing minerals are bismite, an oxide; bismuthinite or bismuth glance, a sulphide; and bismutite, a carbonate. Native bismuth is also mined in Bolivia. The abundance of bismuth in the earth's crust is estimated to be 0.00002 per cent - about the same as silver or cadmium.

Most of the bismuth in copper concentrates accompanies the copper matte during smelting. In the conversion of copper matte to blister copper, bismuth is fumed and then collected in the baghouse with lead, arsenic or antimony oxide dusts. These dusts are then processed by lead smelters.

Bismuth in lead concentrates stays with the impure lead bullion during reduction in the blast furnace. The first stages of pyrometallurgical refining produce a bismuth-containing dross and then a bismuth-lead alloy which may be further refined to remove impurities, precious metals and remaining lead and zinc. As a last step, bismuth is given a final oxidation with air and caustic soda or chlorine to yield a dross and a bismuth product with purity of 99.99+ per cent. High purity grades of 99.9999+ per cent are also available.

Alternatively, at electrolytic lead refineries, treatment of lead anodes leaves pure lead on the cathode and a cell slime which may contain bismuth. The slime is processed to yield an impure metal, which is then refined. Bismuth is leached from roasted tin concentrates with hydrochloric acid, precipitated as bismuth oxychloride, reduced to metal by wet or dry methods and then refined. Product forms from all of these processes may include ingots, shot, needles, powder and pellets.

CANADIAN DEVELOPMENTS

Bismuth metal is recovered at Cominco Ltd.'s Trail, British Columbia electrolytic lead refinery and is refined to 99.99+ per cent purity. Some bismuth is refined further at Cominco Electronic Materials Division for use in electronics and research applications. The ores of the Sullivan mine, the major source of lead concentrate feed to the smelter/refinery, contain traces of bismuth.

Bismuth-lead alloys are produced at Brunswick Mining and Smelting Corporation Limited's pyrometallurgical lead refinery at Belledune, New Brunswick. The bismuth refinery has been closed since 1974. Most feed is from the Brunswick No. 12 mine in the form of a lead concentrate with small amounts of contained bismuth.

Byproduct recovery of bismuth in ores and concentrates at Terra Mines Ltd.'s Camsell River, N.W.T. silver mines was scaled down in 1984 and halted in April 1985 because of falling silver prices and high costs. Total production of bismuth in Canada in 1986 was approximately 260 t, 60 t more than in 1985.

Consumption of bismuth in Canada was approximately 7 t in 1985.

WORLD DEVELOPMENTS

Western world consumption of bismuth can only be estimated since statistical coverage is incomplete. Japanese consumption is estimated at 350 t in 1986. Consumption in the United States, the largest single market, is about 1 200 t annually. European consumption is estimated to be around 1 000 t while consumption in other countries likely totalled several hundred tonnes in 1986.

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Reported net metal exports to socialist countries, estimated at over 400 t in 1985, likely fell in 1986. Estimated sales of over 100 t by the People's Republic of China were reported in 1986. Offsetting this were later purchases of 130 t by China in early-July and reports of purchases of 120-150 t and 200 t by the socialist world made in July and December, respectively.

Major western world mine producers of bismuth-containing ores and concentrates are Australia, Mexico, Peru, Canada and Japan. These countries produce bismuth from a variety of ores which may contain lead, silver, copper or zinc. Mining of bismuth ores resumed in Bolivia in 1985.

Major western world producers of by-product bismuth at the smelting and refining stage are Mexico, Japan, Peru, the United Kingdom, Bolivia, Canada, United States, the Federal Republic of Germany, France and Belgium.

Production of refined bismuth can be highly variable from year to year because of the byproduct nature of production, the large production capacity in relation to demand, and variations in the bismuth content of smelter feed. Estimated western world production of refined bismuth in 1986 is under 4 000 t. World production capacity has been estimated to be about 6 000 tpy.

ASARCO Incorporated is the sole primary producer of bismuth in the United States, but provides only one-tenth of total U.S. demand. Production of bismuth is a byproduct mainly of lead production at ASARCO's lead refinery at Omaha, Nebraska and its lead smelters at East Helena, Montana and El Paso, Texas. The El Paso smelter was shut down indefinitely in 1985 and production at East Helena was intermittently cut back to a five-day cycle during 1985 and 1986 because of feed shortages. Some 95 per cent of concentrate feed is sourced outside the company.

In 1986, Industrias Penoles SA de CV purchased the 40 per cent share of its Met-Mex Penoles SA de CV affiliate held by Bethlehem Steel International Corp. for $20 million, an amount equivalent to 18 per cent of Met-Mex Penoles' equity. The Torreon, Mexico lead smelter/refinery of Met-Mex has a capacity of 180 000 tpy of lead and 500 tpy of bismuth. Production of refined bismuth in 1985 was 372 t. The plant is also the world's largest single silver producer from ores and concentrates. A short-lived strike beginning April 7, 1986 affected bismuth shipments temporarily, but the issues were resolved by mid-month and a force majeure declaration was avoided.

After halting mining of bismuth ores in 1980, the Bolivian producer, Corporacion Minera de Bolivia (Comibol) resumed operations at the Tasna-Rosario deposit in Potosi from June, 1985 to May, 1986 and at the Queschisla mine in July, 1985. Start-up of the 580 tpy capacity bismuth refinery at Telemayu, after several delays, was scheduled for September 1986, but the restructuring of Comibol and management-labour negotiations apparently resulted in further delay. The World Bank later announced that it would provide $US 45 million towards the state-owned company's reorganization. Production was originally targeted for 300-400 tpy of refined metal, depending on market conditions.

The force majeure on bismuth shipments from Empresa Minera del Centro del Peru S.A. (CENTROMIN-Peru), the Peruvian state-owned producer, lasted from early-March, 1986 to mid-June, 1986 because of labour-management-government negotiations over wages. Production of bismuth metal at the La Oroya metallurgical complex fell by about 130 t as a result. Capacity of the refinery is some 800 tpy of bismuth metal.

In the United Kingdom, Mining and Chemical Products Ltd. (MCP) processed bismuth ores, concentrates and bullion to 99.99 per cent and 99.997 per cent purities as well as alloys. Production has been in the order of "several hundred tonnes per year" in recent years, but production was believed to have been cut back significantly with falling prices in 1986. Capper Pass & Son Ltd. - a major U.K. tin producer - has a capacity to produce 250 tpy of bismuth (alloys).

France's Mines & Produits chimiques de Salsigne S.A. delayed re-opening of a bismuth-producing gold mine and bismuth refinery originally scheduled for March, 1985. The company had hoped to begin producing some 100 tpy of bismuth in late-1985 or early-1986 but now expects to re-open the plant in mid-1988.

Belgium's Métallurgie Hoboken-Overpelt SA produces bismuth at its Hoboken lead refinery from a variety of complex lead and bismuth bearing materials. A five-year (1984-89) program to diversify metallurgical operations and improve recoveries of metals from slag is currently under way. Refining capacity for bismuth is about 300 tpy.

West Germany's Norddeutsche Affinerie AG (Degussa AG 40 per cent; Metallgesellschaft AG 40 per cent; British Amalgamated Metal Investments Ltd. 16 per cent; The British Metal Corp. Ltd. 4 per cent) produces refined bismuth at its Hamburg copper and lead metallurgical works. Degussa AG refines bismuth metal at its Bonn, West Germany cadmium and bismuth refinery.

Italy's Sameton SpA typically produces some 30 tpy of bismuth metal from its 110 tpy refinery. Output could rise substantially with the commissioning of the newly constructed 84 000 tpy KIVCET lead smelter in 1987.

Hollandse Metallurgische Industrie Billiton BV produces refined bismuth alloys and high purity metal at its Arnhem, Netherlands facilities from the smelting and refining of complex tin and tungsten ores.

In Yugoslavia, bismuth production at Sour Rudarsko-Metalursko-Hemijski Kombinat Olova i Cinka (Trepca Works) is a byproduct of electrolytic refining of lead bullion from its furnaces at Kosovska, Mitrovica.

In Japan, domestic shipments were estimated to be some 319 t in 1985 and exports rose to 248 t. Domestic shipments are expected to have risen in 1986. The major producers are Toho Zinc Co. Ltd. (capacity 180 tpy, typical production 80-90 tpy) Dowa Mining Co., Ltd. (capacity 240 tpy, typical production 180 tpy); Nippon Mining Company Limited (typical production 120 tpy); Mitsubishi Metal Corporation (capacity 50 tpy, typical production 40-45 tpy); Sumitomo Metal Mining Co. Ltd. (capacity 60 tpy, typical production 24-36 tpy) and Mitsui Mining & Smelting Co. Ltd., (typical production 160 tpy). Production in 1985 was 642 t of bismuth, but was expected to be higher in 1986. In the first half of 1986 bismuth production was 332 t or 8.2 per cent higher than in the first half of 1985.

Korea Mining & Smelting Co. Ltd. produces some 36 tpy of bismuth metal at its Changhang copper-lead-tin metallurgical works. Korea Tungsten Mining Co. Ltd. also produces bismuth metal as a byproduct of tungsten production.

In Australia, bismuth is recovered as crusts during the refining of lead. Peko-Wallsend Ltd. cut back its mine production of bismuth in 1981 because of declining prices for the major products - copper and gold - at its Tennant Creek, Australia, operation.

USES

Bismuth is used in a wide variety of applications. Fusible alloys - bismuth alloyed with tin, lead, and cadmium, for example - melt at specific temperatures for fire protection systems. They are re-useable for applications such as blocking complex shapes for machining; grinding and polishing of lenses and costume jewellery; and die assembly. These alloys are also used as moulds for plastic extrusion, as filler for tube-bending, as solder alloys, and as thermal fuses.

Bismuth is added to steel and aluminum to improve machineability and to iron to improve processes for and properties of spheroidal graphite iron castings. Bismuth alloys provide self-lubricating properties to bearings. For powder metallurgy products, bismuth alloy surface coatings are useful in applications subject to abrasion in chemical and food handling apparatus. Bismuth alloys in electronic cabinetry also aid EMI, RFI, and ESD shielding. Other electronics-related applications include a number of electronic components; solder, pastes and compounds; energy storage cells; and magnetic or optical recording devices. Nuclear-related applications include reactor seal plugs and cooling fluid. Bismuth can substitute for silver for unconventional high-resolution colour and black-and-white photographic images. Bismuth compounds are used in pharmaceuticals, medical diagnostics, cosmetics and chemicals. For example, bismuth salts are used as a treatment for indigestion and stomach ulcers. Bismuth oxychloride, either deposited on mica or in dispersed form, provides a pearlescent lustre to lipsticks, face powders, blushes, nail color, eye-shadow and hairspray. Bismuth is also used in metallized paints. Catalysts containing bismuth are also used for production of acrylonitrile.

Research is on-going for possible uses in metallurgical additives and alloys, electric contacts; ceramics, glasses and electronic devices; visual display devices; electrochemical applications; opto electronic recording media; plastics/elastomers; pigments; health and beauty care products; and catalysts. Metallurgical research on extraction, determination and recovery is also carried out worldwide.

Researchers at the Japanese Research and Development Corp. have developed a ferromagnetic glass for opto electronic uses. The glass is produced by rapid cooling of molten zinc ferrite and bismuth iron perdyskite - at a rate of between 100,000 and 1 million degrees Centigrade per second.

Bismuth Institute

The Bismuth Institute, incorporated in 1973 in Bolivia, is now headquartered in Brussels. This non-profit organization is supported by financial contributions from its sponsors - members from Australia, Bolivia, England, France, Japan, Mexico and Peru - and is directed by a board which consists of executives of member companies. The Institute provides technical and research information on bismuth, solicits research proposals and publishes a quarterly bulletin.

PRICES

In the United States, the Metals Week Major Producer List Price reached a nominal $US 6.50 per pound in 1985. The market later weakened, and this list price was suspended by MCP-Peko. ASARCO Incorporated, the only U.S. producer of bismuth, no longer publishes a list price. European Free Market prices for 99.99+ per cent bismuth (tonne lots) fell from $US 3.40-3.70 per pound at the beginning of 1986 to $2.17-2.38 by July 21 before recovering to $2.50-2.65 by the end of July. Thereafter, the price slid to a low of $2.05-2.25 by mid-November, 1986. The price rose to $US 2.15-2.25 per pound near the end of December.

OUTLOOK

Excess bismuth production capacity has contributed to price volatility. Occasional supply disruptions and socialist bloc purchases and sales have also contributed to market instability in this minor metal. Existing major bismuth uses remain relatively specialized, or are subject to material or process-related substitution. Development of new dissipative uses in broad applications would enhance the stability of this market, otherwise the outlook will likely remain volatile.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
CANADA					
33100-1	Bismuth, metallic, in its natural state	free	free	free	free
35106-1	Bismuth metal, not including alloys, in lumps, powders, ingots or blocks	free	free	25	free
UNITED STATES (MFN)				1986	1987
				(%)	
601.66	Bismuth ores			Remains free	
632.10	Bismuth metal unwrought and waste and scrap			Remains free	
632.64	Alloys of bismuth: containing by weight not less than 30 per cent lead			Remains free	
632.66	Other alloys of bismuth			5.9	5.5
633.00	Bismuth metal wrought			5.9	5.5

Sources: The Customs Tariff, 1986, Revenue Canada; Customs and Excise; Tariff Schedules of the United States Annotated 1986, USITC Publication 1775; U.S. Federal Register Vol. 44, No. 241.

TABLE 1. CANADA, BISMUTH PRODUCTION, 1985 AND 1986, AND CONSUMPTION, 1983-85

	1985		1986P	
	(kilograms)	($)	(kilograms)	($)
Production, all forms[1]				
New Brunswick	163 400	3,197,412	174 470	1,684,665
British Columbia	33 201	649,677	81 986	763,454
Ontario	1 050	20,456	3 140	29,240
Manitoba	188	3,679	95	885
Northwest Territories	3 092	60,504	20	186
Yukon Territory	558	10,919	695	6,472
Total	201 489	3,942,647	260 406	2,424,901
Imports, primary forms and fabricated materials			(Jan.-Sept.)	
United States	11 127	194	12 482	130
Mexico	1 093	14	-	-
Total	12 220	208	12 482	130

	1983	1984	1985
		(kilograms)	
Consumption, refined metal (available data)			
Fusible alloys and other alloys	6 841	8 424	5 921
Other uses	400	974	1 363
Total	7 241	9 398	7 284P

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Refined bismuth metal from Canadian ores, plus recoverable bismuth content of bullion and concentrates exported.

P Preliminary; - Nil.

TABLE 2. CANADA, BISMUTH PRODUCTION AND CONSUMPTION, 1970, 1975 AND 1980-86

	Production all forms[1]	Consumption[2]
	(kilograms)	
1970	267 774	11 135
1975	156 605	29 267
1980	149 366	10 271
1981	167 885	10 094
1982	189 000	10 074
1983	253 023	7 241
1984	166 000	9 398
1985	201 489	7 284P
1986P	260 406	..

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Refined bismuth metal from Canadian ores, plus recoverable bismuth content of bullion and concentrates exported. [2] Refined bismuth metal reported by consumers.

P Preliminary; .. Not available.

TABLE 3. UNITED STATES CONSUMPTION OF BISMUTH BY PRINCIPAL USES, 1984 AND 1985

	1984	1985
	(tonnes)	
Chemicals[1]	714	601
Metallurgical additives	192	303
Fusible alloys	276	277
Other alloys	9	9
Other uses[2]	10	9
Total	1 201	1 199

Source: U.S. Bureau of Mines.

[1] Includes industrial and laboratory chemicals, cosmetics and pharmaceuticals.

[2] Includes experimental uses.

TABLE 4. MONTHLY AVERAGE PRICES - BISMUTH

	1984	1985
	(Major producer, $US per pound)	
January	2.30	6.50
February	2.30	6.50
March	2.49	6.50
April	2.75	6.50
May	3.59	6.50
June	4.90	6.50
July	4.00	6.50
August	4.72	6.50
September	5.00	6.50
October	5.54	6.50
November	6.50	*
December	6.50	*
Year	4.14	*

Source: Metals Week.
* List Price suspended in November 1985.

Cadmium

M.J. GAUVIN

Cadmium metal is recovered principally as a by-product of zinc smelting and refining. Cadmium is a relatively rare element in the earth's crust, occurring most commonly as the sulphides greenockite and hawleyite which are found associated with zinc sulphide ores, particularly sphalerite. There are no ores specifically mined for cadmium. Reserves at any time are a function of zinc reserves.

Smelter residues from which cadmium is extracted may be stockpiled in times of low demand with the result that refined cadmium production is not always directly related to production of the principal metals. During the past seven years, cadmium production in Canada has varied from 2.1 to 2.7 kg of cadmium to each tonne of zinc metal produced. Because of the involuntary production of cadmium with zinc, cadmium production currently exceeds demand and prices have weakened.

Cadmium metal is produced in varying shapes and degrees of purity for various uses. The most common forms are balls, sticks, slabs, ingots, rods and sponge.

Cadmium is toxic, and care must be taken during the production and use of cadmium and its compounds, to ensure that exposure to fumes, dusts and effluents is minimized. It releases fumes during thermal treatment which quickly oxidize and these can be inhaled or ingested. Acute exposure can be very toxic, causing irreversible kidney damage but there is said to be insufficient evidence to consider cadmium as an occupational carcinogen. Its toxicity was publicized in the early 1960s when nearly 100 persons in Japan died from itai-itai disease. Sophisticated methods are now available to measure cadmium in the workplace and in humans. Some provinces have instituted or are in the process of proposing regulations on exposure limits aimed at preventing kidney disfunction.

Canada, in 1985, was the non-socialist world's second largest producer of cadmium metal, after Japan. The next three largest producers were the United States, Belgium and the Federal Republic of Germany. Production of cadmium in the non-socialist world, as reported by the World Bureau of Metal Statistics, decreased in 1985 to 14 153 t from 15 123 t in 1984. While data is not yet available for 1986, non-socialist world production is estimated to be about the same as that of 1985 and Canadian production is estimated at 1 605 t.

USES

Cadmium is a soft, ductile, silver-white, electropositive metal. It is used mainly for coating iron and steel products to protect them against oxidation. Cadmium coatings may be applied by electroplating, mechanical plating or vacuum and ion deposition. The high ductility of cadmium is an advantage where the plated parts are to be formed. The good soldering characteristics of cadmium plate is an advantage in electrical applications. A cadmium coating, like a zinc coating, protects metals that are lower in the electromotive series by physical enclosure and by sacrificial corrosion. Cadmium is usually preferred to zinc as a coating because it is more ductile, can be applied more uniformly in recesses of intricately shaped parts, has a more aesthetic appearance and gives greater protection with the same thickness of plating than with zinc plating. Cadmium coatings are particularly useful in the electrical, electronic, automotive and aerospace industries.

The second largest use, according to the Statistics Canada survey, is in the manufacture of pigments and chemicals. Cadmium sulphides are used in yellow to orange colours and cadmium sulphoselenides for pink, red and maroon. Cadmium-containing pigments demonstrate good reflectance, heat

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stability and colour intensity. Cadmium compounds are used as stabilizers in the production of plastics and cadmium phosphors are used for picture tubes in television sets.

Cadmium-bearing rechargeable alkaline batteries, such as nickel-cadmium, silver-cadmium and mercury-cadmium, have the advantage of long life, maximum current delivery with a low voltage drop, small size, excellent performance under a wide temperature range and a low rate of self-discharge. They find wide use in aircraft, satellites, missiles, calculators, and a broad assortment of portable tools and appliances.

Other uses for cadmium are catalysts in the production of primary alcohols and esters; low melting point alloys used in fire detection; bearing alloys, brazing alloys and solders; and copper hardeners for railway catenary and trolley wires.

PRICES

North American prices, which are quoted on a delivered basis, are best represented by the "U.S. Producer" quotations published in Metals Week, and European prices by the "European sticks, free market price" quoted by Metal Bulletin. All quoted prices are for cadmium having a minimum purity of 99.95 per cent. Published U.S. producer prices were $1.00/lb. at the beginning of 1986, rose to a high of $1.35 during April and maintained that price until the end of the year.

OUTLOOK

In the long term, the cadmium supply will continue to be dependent on trends established by the zinc industry. As the level of metal production is determined by the amount of zinc metal production, periods of oversupply, such as is currently being experienced, will reoccur in the future. It is expected that greater usage in its traditional markets, particularly that of rechargeable nickel-cadmium batteries, and possible new uses would gradually absorb the excess supply.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
CANADA					
32900-1	Cadmium in ores and concentrates	free	free	free	free
35102-1	Cadmium metal, not including alloys, in lumps, powders, ingots, or blocks	free	free	25	free
UNITED STATES					
601.66	Cadmium in ores and concentrates		free		
632.14	Cadmium metal, unwrought, waste and scrap		free		
632.86	Cadmium alloys, unwrought containing by weight 96% or more, but less than 99% silicon		9		

		1986	1987
		(%)	
632.88	Cadmium alloys, unwrought, other	5.9	5.5
633.00	Cadmium metal, wrought	5.9	5.5

EUROPEAN ECONOMIC COMMUNITY (MFN)

		1986	Base Rate	Concession Rate
			(%)	
26.01	Cadmium in ores and concentrates	free	free	free
81.04	Cadmium metal, unwrought, waste and scrap	4	4	4
	Cadmium metal, other	6	6	6

JAPAN (MFN)

		1986	Base Rate	Concession Rate
			(%)	
26.01	Cadmium in ores and concentrates	free	free	free
81.04	Cadmium metal:			
	Unwrought	5.7	10	5.1
	Waste and scrap	5.5	10	4.8
	Powders and flakes	6.3	10	5.8
	Cadmium metal, other	7.6	15	6.5

Sources: The Customs Tariff, January 1986. Revenue Canada, Customs & Excise; Tariff Schedules of the United States Annotated 1986, USITC Publication 1775; U.S. Federal Register, Vol. 44, No. 241; Official Journal of the European Communities, L 331, Vol. 28; 1986; Customs Tariff Schedules of Japan, 1986.

TABLE 1. CANADA, CADMIUM PRODUCTION, EXPORTS AND DOMESTIC SHIPMENTS, 1970, 1975 AND 1980-86

	Production		Exports	Producers'
	All Forms[1]	Refined[2]	Cadmium Metal	Domestic Shipments
	(kilograms)			
1970	1 954 055	836 745	702 630	157 307
1975	1 191 674	1 142 508	637 797	98 820
1980	1 033 000	1 302 955	1 095 825	88 232
1981	833 788	1 293 265	1 452 904	131 175
1982	886 055	1 162 390	769 530	84 910
1983	1 107 000	1 296 000	1 365 111	91 310
1984	1 605 300	1 756 707	1 369 422	78 000
1985	1 716 731	1 696 192	1 477 416	76 000
1986	1 420 590	1 605 145	1 089 261[3]	87 018

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Production of refined cadmium from domestic ores plus recoverable cadmium content of exported ores and concentrates. [2] Refined metal and cadmium sponge from all sources. [3] For the January to September period.

TABLE 2. CANADA, CADMIUM METAL CAPACITY, 1986

Company and Location	Annual Capacity
	(tonnes)
Cominco Ltd. Trail, British Columbia	640
Canadian Electrolytic Zinc Limited Valleyfield, Quebec	550
Falconbridge Limited Timmins, Ontario	650
Hudson Bay Mining and Smelting Co., Limited Flin Flon, Manitoba	160
Total Canada	2 000

Sources: Mining & Mineral Processing Operations in Canada, 1983. Energy, Mines and Resources Canada.

TABLE 3. CANADA, CADMIUM PRODUCTION AND EXPORTS, 1984-86, AND CONSUMPTION, 1983-85

	1984		1985		1986P	
	(kilograms)	($)	(kilograms)	($)	(kilograms)	($)
Production						
All forms[1]						
Ontario	930 000	4,490,000	898 297	3,268,004	724 105	2,769,702
British Columbia	114 000	553,000	193 443	703,746	300 966	1,151,195
Manitoba	149 000	720,000	181 539	660,439	115 282	440,954
Quebec	90 000	434,000	123 839	450,526	54 158	207,154
New Brunswick	89 000	432,000	67 081	244,040	52 075	199,187
Saskatchewan	17 000	82,000	13 111	47,698	5 107	19,534
Northwest Territories	214 000	1,034,000	238 042	865,997	167 154	639,364
Newfoundland	-	-	-	-	-	-
Yukon	2 000	9,000	1 379	5,017	1 743	6,667
Total	1 605 000	7,754,000	1 716 731	6,245,467	1 420 590	5,433,757
Refined[2]	1 756 707	..	1 696 192	..	1 605 145	..
Exports					(Jan.-Sept.)	
United States	824 667	3,458,447	906 034	2,875,839	808 293	2,826,584
United Kingdom	511 341	1,754,074	460 234	1,109,348	180 578	481,472
Netherlands	28 060	85,192	110 952	347,928	99 870	231,137
Others	5 357	62,995	196	23,091	520	54,972
Total	1 369 425	5,360,668	1 477 416	4,356,206	1 089 261	3,594,165

	1983	1984	1985P
		(kilograms)	
Consumption			
Cadmium metal[3]			
Plating	15 641	13 327	15 854
Solders	148	226	3 717
Other uses[4]	17 096	15 257	15 366
Total	32 885	28 810	34 937

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Production of refined cadmium from domestic ores, plus recoverable cadmium content of exported ores and concentrates. [2] Refined metal from all sources and cadmium sponge. [3] Available data reported by consumers. [4] Mainly chemicals, pigments and alloys other than solder.
P Preliminary; - Nil; .. Not available.

TABLE 4. CADMIUM METAL PRICES, 1985 AND 1986

Month	Average Monthly Prices Metals Week U.S. Producer	 New York Dealer	 Metal Bulletin European Free Market - Sticks	 Cominco
1985	($US/lb.)		($US/lb.)	($Cdn/lb.)
January	1.40	1.179	1.19-1.24	1.75
February	1.40	1.168	1.12-1.17	1.75
March	1.40	1.053	0.90-0.98	1.75
April	1.40	1.001	0.92-0.98	1.75
May	1.40	0.917	0.84-0.90	1.75
June	1.40	0.821	0.73-0.79	1.75
July	1.10	0.838	0.76-0.82	1.25
August	1.00	0.864	0.83-0.88	1.25
September	1.00	0.808	0.81-0.86	1.25
October	1.00	0.806	0.82-0.86	1.25
November	1.00	0.777	0.77-0.82	1.25
December	1.00	0.797	0.77-0.81	1.25
Average	1.21	0.919	0.87-0.93	1.50
1986				
January	1.00	0.822	0.78-0.83	1.25
February	1.00	0.880	0.76-0.81	1.25
March	1.00	0.985	0.78-0.82	1.25
April	1.17	1.244	1.04-1.09	1.50
May	1.35	1.306	1.08-1.14	1.75
June	1.35	1.194	1.03-1.08	1.75
July	1.35	1.066	0.94-0.99	1.75
August	1.35	1.074	0.89-0.94	1.75
September	1.35	1.196	0.96-1.01	1.75
October	1.35	1.148	0.97-1.01	1.75
November	1.35	1.045	0.87-0.92	1.75
December	1.35	1.014	0.86-0.91	1.75
Average	1.25	1.081	0.91-0.96	1.60

Sources: Metals Week, Cominco Ltd., Metal Bulletin.

TABLE 5. WESTERN WORLD CADMIUM METAL PRODUCTION, 1982-86

Continent and Country	1982	1983	1984	1985	(Jan.-June) 1986P
			(tonnes)		
Europe					
Austria	49	46	48	53	24
Belgium	1 001	1 217	1 450	1 293	713
Finland	566	616	614	564	259
France	580	447	447	365	251
Germany, F.R.	1 030	1 094	1 111	1 095	632
Italy	475	386	515	360	160
Netherlands	497	513	636	598	279
Norway	102	117	152	164	74
Spain	286	278	290	268	120
United Kingdom	354	340	39[illegible]	370	160
Yugoslavia	174	48	48	48	24
Africa					
Algeria	30	30	24	24	12
Namibia	110	51	41	60	49
Zaire	281	308	300	280	139
Asia					
India	131	131	143	190	85
Japan	2 021	2 215	2 400	2 555	1 333
Republic of Korea	320	460	460	460	230
Turkey	10	10	12	16	8
Americas					
Canada	1 162	1 296	1 774	1 712	895
Mexico	942	847	894	852	352
Peru	425	443	n.a.	n.a.	n.a.
United States	1 351	1 382	2 066	1 678	1 161
Other Americas	94	210	249	269	118
Australia	1 010	1 104	1 060	879	418
Western World	13 001	13 589	15 123	14 153	7 496

Sources: World Metal Statistics, August 1985; Energy Mines and Resources Canada.
P Preliminary; n.a. Not available.

Cement

D.H. STONEHOUSE

SUMMARY 1986

In the last quarter of 1985 a survey by the Conference Board of Canada identified optimism towards business investment in Canada. This was undoubtedly tempered by soft oil prices which followed but reflected in real increases of over 9 per cent in total non-residential building construction in 1986. With expected strengthening of oil prices in 1987 construction activity could show signs of further improvement. Heavy or engineering construction activity has remained relatively stable and is not much greater than 70 per cent of record levels reached in 1982. From a regional perspective, the non-residential building construction sector showed substantial increase in Ontario and Quebec, slight improvement in Atlantic Canada and a decline in western Canada.

Demand for cement in Canada grew in 1986 to over 7.5 million tonnes (t) and exports of total cement and clinker to the United States rose by over 10 per cent to help satisfy demand from the construction industry in that country. Total shipments from Canadian producers were about the same as last year at a total of just over 10 million t from a production capacity of about 16.54 million tpy, unchanged in any major way since 1983. Plant closures for extended periods during 1986 were not uncommon.

On the Canadian scene corporate changes have taken place during 1986. Imasco Limited acquired all assets of Genstar Corporation of Vancouver for $2.5 billion and in keeping with its stated intentions to retain the financial services areas and dispose of the rest, announced in mid-year the sale of Genstar's Western Canadian Cement operations to SA Cimenteries Cementbedrijven NV (CBR) of Belgium for $452 million. CBR will operate in Canada under CBR Cement Canada Limited.

Denison Mines Limited sold its 54 per cent controlling interest in Lake Ontario Cement Limited to Société des Ciments Français for $84.3 million ending L.O.C.'s claim to being the only Canadian controlled, public cement company. Ciment Français also owns Coplay Cement in Nazareth, Pennsylvania, U.S.A. The Canadian cement industry is now about 83 per cent foreign controlled.

Exports of Canadian cement and clinker are mainly to the United States, in particular to the states of New York, Vermont, Michigan and Minnesota. Canadian cement production efficiencies and a strong American dollar continue to make Canadian cement and clinker competitive in bordering states, quite different than being imported as a supplement to United States production. Imports from Mexico, Spain and Venezuela have added to the concerns of the United States cement producers. Of protectionist measures being considered, the Buy America provisions within the United States Surface Transportation Assistance Act, 1982 (STAA) are of particular concern to the Canadian cement exporters. STAA provides substantial funding for highway and bridge projects in the United States, representing about 6 per cent of total United States cement consumption. Through 1983 and early-1984, Canadian exporters were effectively excluded from supplying these projects by Buy America restrictions on foreign cement. Congress lifted these restrictions in March, 1984 affording Canadian cement full access to STAA-funded projects. By late-1986, bills which could influence this situation were before both Congress and the Senate.

The United States cement industry reaction has led to the formation of an American Cement Trade Alliance (ACTA) to lobby for "fair trade vs free trade" despite the fact that imports are brought in by U.S. cement producers themselves and ACTA's membership accounts for 45 per cent of total imports. A second group was formed in late-1985, the Cement Free Trade Alliance (CFTA), representing many of the importers and lobbying to "maintain the status quo". In such a setting, anti-dumping claims may be difficult to justify in that injury to the domestic cement industry from imports must be proven.

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Major Canadian cement producers strengthened their United States position during the 1980s with acquisitions ranging from cement storage and distribution facilities and clinker grinding plants to full clinker producing and grinding capacity. In 1985, Lafarge Corporation, which wholly owns both Canada Cement Lafarge Ltd. in Canada and General Portland Inc. in the United States, announced its decision to close General Portland's Florida plants and to make up the lost production with imports from Mexico. The Florida plants account for 19 per cent of General Portland's capacity of 6 million t. The company is planning to accommodate further imports into Texas and on both the east and west coasts. Lafarge also strengthened its position in the Great Lakes region with the purchase from National Gypsum Company of six cement distribution terminals, a 50 per cent interest in eight other terminals and an option to buy the other half interest from National as well as National's Alpena, Michigan cement plant.

Between 1980 and 1984 St. Lawrence Cement Inc. spent some $180 million on capital investment about $100 million of which was to acquire cement production and terminal facilities in northeastern United States. In 1985, the company announced the acquisition of the Hagerstown, Maryland cement plant, along with a distribution terminal at the port of Baltimore, from Lone Star Industries, Inc. of Greenwich, Connecticut for $US 65 million. During the year St. Lawrence also acquired Custom Concrete Ltd. of Toronto, with six ready-mix plants and three aggregate quarries.

THE CANADIAN INDUSTRY

The Canadian cement industry is strongly regionalized on the basis of market availability. Capacity is concentrated near growth areas and, fortunately for some, these areas are convenient to foreign market access as well. Some plants were located to take advantage of existing United States markets and to be in a position to utilize waterborne, high-bulk transportation facilities.

St. Lawrence Cement's acquisition of Lone Star's Hagerstown, Maryland plant is a continuation of the company's expansion policy. In 1984, the company purchased the Catskill, New York plant of Lone Star for $US 30 million and earlier had purchased a terminal operation at Wilmington, Massachusetts to improve service to the Boston area and had added to its terminal facility at Oswego, New York. St. Lawrence now has about 1.1 million t of capacity in the United States and continues to ship into the northeastern region from its Canadian plants.

With the acquisition of General Portland Inc. of Dallas, Texas in 1982, Canada Cement Lafarge Ltd. became the largest cement producer in North America with a capacity of 11.663 million tpy. In early-1983 a corporate reorganization established Dallas-based Lafarge Corporation which wholly-owns both Canada Cement Lafarge Ltd. and General Portland Inc. The move was designed to give the corporation access to the United States money market and to maintain the overall 52 per cent control of both companies by Lafarge Coppée of Paris, France.

St. Marys Cement Company has two United States affiliates - St. Marys Wyandotte Cement Inc. and St. Marys Wisconsin Cement Inc. The former operates a 300 000 tpy grinding plant near Detroit, the latter a 150 000 tpy grinding plant in Milwaukee and distribution terminals in Green Bay, Wisconsin and Waukegan, Illinois.

A typical feature of the Canadian cement industry is its diversification and vertical integration into related construction and construction materials fields. Many cement manufacturers also supply ready-mix concrete, stone, aggregates and concrete products such as slabs, bricks and pre-stressed concrete units.

Lake Ontario Cement Limited, for example, is well integrated into the concrete products field. In 1984 it brought three companies into its corporate structure: Soil Protection Systems Inc. of Milton, Ontario; Euclid Chemical Canada Inc. of Markham, Ontario; and United Aggregates Ltd. of Brampton, Ontario. The company also began a $1.5 million expansion program at its Vibrapipe Ltée operation in Quebec. With the 1985 acquisition of these ready-mix plants the company now has two cement subsidiary operations in the United States, five operations in its Pipe Group, six in its Building Products Group and two operations attached to the corporate offices.

Cement manufacture is energy-intensive. It is obvious that research should be concentrated in this area, and specifically within the pyroprocessing sector where over 80 per cent of the energy is consumed. Raw material grinding and finish grinding are being studied to determine optimum particle size for energy consumed. Energy conservation programs adopted by the Canadian cement industry more than reached the goal of a 9 to 12 per cent reduction in energy consumption per unit of production, based on 1974 calculations. In 1985 the Canadian cement industry on average consumed 4,968 megajoules a tonne of production of which 4,282 megajoules was derived from fossil fuels.

The fuel mix has changed quite dramatically from that in 1974 when natural gas, petroleum products and coal/coke accounted for 49.5, 39.7 and 10.8 per cent respectively. In 1985, in the same order, the respective percentages were 33.1, 4.4 and 62.5. The dry process now accounts for over 70 per cent of Canadian portland cement capacity. In 1985 dry process plants accounted for 83.6 per cent of total Canadian cement production.

Energy conservation demonstration projects have been funded through the Conservation and Non-Petroleum Sector of Energy, Mines and Resources. One such project has dealt with the use of Coal Water Fuel in two cement kilns in Richmond, B.C. The optimum economic level of replacement of other fuels exceeded the target after a trial lasting over a year. The initial aim was to replace a minimum of 60 per cent of the natural gas previously used with a target high of 80 per cent. The trial indicated 95 per cent could be replaced by the Coal Water Fuel. Total coal consumption of 100 000 tpy would result. The industry is represented on the Industrial Minerals Task Force on Energy Conservation and continues to play an active role in this organization. Through the Canada Centre for Mineral and Energy Technology, a branch of Energy, Mines and Resources Canada and through the Building Research Division of the National Research Council a continuing program of concrete research is managed. Concrete research has generally been confined to strength determination, durability, placement and curing. Recently much research has been done on the use of superplasticizers, a group of admixtures described chemically as naphthalene or melanine sulphonate polymers, which have been found to provide greater workability over short time spans or to provide high-strength by permitting lower water-cement ratios.

Energy, Mines and Resources Canada research on the use of blast furnace slag from the steel industry to manufacture a slag cement will be applied by Reiss Lime Company of Canada, Limited. The company will produce 200 000 tpy of slag cement at Spragg, Ontario, using granulated slag from The Algoma Steel Corporation, Limited, Sault Ste. Marie plant. Principal use for the cement will be in mine backfill.

Two major research projects currently sponsored through CANMET deal with the use of fly ash in concrete and with the alkali reactivity of certain concrete aggregates.

Research in the private sector is conducted on behalf of all cement producers by the Portland Cement Association (PCA), a non-profit research group sponsored by the cement industry. Individual producers generally have research facilities varying in size from a customer service unit to a large laboratory, mandated, as in the case of Canada Cement Lafarge's new Montreal-based facility, "to develop new manufacturing processes and improve cement and concrete products tailored to the Canadian and United States markets."

The three plants in the **Atlantic region** constitute just over 5 per cent of total Canadian clinker producing capacity. All three obtain raw materials at or near the plant site. North Star Cement Limited is undergoing extensive renovation at its Corner Brook, Newfoundland plant to improve fuel efficiency. Canada Cement Lafarge's plants at Brookfield, Nova Scotia and at Havelock, New Brunswick were closed for periods in 1985 despite a slight growth to 445 000 t in regional consumption.

In the **Quebec region** the five clinker-producing plants have 25 per cent of the Canadian total in an area that has 26.1 per cent of Canadian population and which, in 1985, consumed about 1.8 million t of portland cement representing 26.4 per cent of total consumption. At its St. Constant plant, south of Montreal, CCL has experimented alternate fuel, as part of a program administered by the federal departments of Environment Canada and Energy, Mines and Resources Canada.

Miron Inc. investigated the use of methane gas from a garbage disposal project on its property with the goal of eventually securing as much as 40 per cent of its fuel requirements from this source. The plant's boiler room was operated in 1983 on methane gas. Input garbage has the energy potential to operate the company's two kilns. Miron is actively investigating new plant sites south of Montreal as time runs out for their quarry-cement plant operation in the heart of Montreal. St. Lawrence Cement Inc. continued its energy-saving programs during 1985 but concentrated its expenditures on expanding further into the United States market through plant and distribution acquisitions. Ciment Québec Inc. began full operation of its new suspension-preheater-precalciner system in 1983, adding about 735 000 tpy to capacity.

Portland cement consumption increased in the **Ontario region** where 40 per cent of the nation's clinker-producing capacity is concentrated. Canada Cement Lafarge Ltd. has brought into production about 3 million t of new cement capacity over the past seven years and currently over half of its operating kilns are less than 10 years old. The limestone for CCL's Bath, Ontario plant is quarried on-site while silica is supplied from Potsdam sandstone at Pittsburgh about 65 km east of Bath and iron oxide is purchased from Hamilton. Gypsum is from Nova Scotia. The Woodstock plant has experimented with the use of selected, processed garbage as fuel. The plant obtains limestone on site, silica from Falconbridge Limited, iron oxide from Stelco Inc. and gypsum from southern Ontario mines.

At Picton, Lake Ontario Cement Limited operates one of the largest cement plants in North America. The four-kiln plant supplies cement and clinker to its United States subsidiaries - Rochester Portland Cement Corp. in New York state and Aetna Cement Corporation in Michigan - and cement to its Ontario markets.

For its Mississauga plant, St. Lawrence Cement Inc. obtains limestone from Odgen Point, 160 km east of Toronto on the shore of Lake Ontario and gypsum is purchased from Nova Scotia or from southern Ontario mines.

With the acquisition of Wyandotte Cement Inc., St. Marys Cement Company began shipments of clinker through a newly constructed lakefront loading facility at Bowmanville. The original plant at St. Marys, constructed in 1912 to serve the Toronto area, has been expanded and modernized over the years, most recently with the installation of a 680 000 tpy kiln and four-stage suspension preheater.

Federal White Cement's plant at Woodstock, can produce up to 100 000 tpy of white cement.

Two companies, Canada Cement Lafarge Ltd. and Genstar Cement Limited, now CBR Cement Canada Limited, operate a total of five clinker producing plants in the **Prairie region** and three in the **Pacific region** along with two clinker grinding plants. This **Western region** has 30 per cent of clinker producing capacity, including the recently completed expansion at Genstar's Edmonton, Alberta plant. Consumption of portland cement in the western provinces accounted for 31 per cent of Canadian total. Recent expansions at Edmonton and at Exshaw increased capacity by about 1.3 million tpy.

CBR continued to increase the productive capacity at its Cadomin limestone property which supplies the Edmonton plant through a 4 500 t unit train and materials handling system. A limestone quarry at Mafeking, Manitoba, near the Manitoba-Saskatchewan border, supplies limestone to Genstar's Regina plant, while the Winnipeg plant is supplied from Steep Rock, Manitoba.

CCL's Winnipeg plant obtains limestone from the company's quarry at Steep Rock on Lake Manitoba, gypsum from Westroc Industries Limited at Amaranth, silica from Beausejour and clay adjacent to the plant site at Fort Whyte. Raw material for the Exshaw plant is mainly from the plant site but gypsum is from Westroc and iron oxide from Cominco Ltd. Limestone from Texada Island supplies the company's Vancouver plant at Richmond. Their Kamloops plant is supplied from resources close to the plant site.

WORLD DEVELOPMENTS

Cement markets are regional and centred in developing urban areas where construction activity is concentrated, or in areas where mining or heavy engineering construction projects are being carried out. The normal market area of a given cement-producing plant depends on transportation costs that the selling price can absorb. A potential large volume of sales could warrant a secondary distribution terminal; water transportation to a distribution system could extend a plant's market area.

Because raw materials for cement manufacture are generally widespread, most countries can supply their own cement requirements if the market volume warrants a plant. Few countries rely entirely on imports for their cement needs. However, some countries rely heavily on export markets for their surplus cement production in order to operate facilities economically. The strong American dollar vis-a-vis European and other currencies has been the principal reason for a major increase in imports of cement and clinker to the United States from as far as Spain and Venezuela. A current glut of shipping bottoms has had an influence on this situation as well.

Cembureau, The European Cement Association, has published Cement Standards of the World - Portland Cement and its Derivatives, in which standards are compared. Cembureau's World Cement Directory lists production capacities by country and by company. Cembureau lists world cement production in 1985 at 940 million t and for the first time shows China leading all other countries at 133 million t ahead of the U.S.S.R. at 129 million t.

USES

Portland cement is produced by burning, usually in a rotary kiln, an accurately proportioned, finely ground mixture of limestone, silica, alumina and iron oxide. The three basic types of portland cement, Normal Portland, High-Early-Strength Portland, and Sulphate-Resisting Portland, are produced by most Canadian cement manufacturers.

Cement has little use alone but, when combined with water, sand, gravel, crushed stone or other aggregates in proper proportions acts as a binder, cementing the materials together as concrete. Concrete has become a widely used and readily adaptable building material which can be poured on-site in large engineering projects, or used in the form of delicate precast panels or heavy, prestressed columns and beams in building construction.

Kiln discharge, in the shape of rough spheres, is a fused, chemically complex mixture of calcium silicates and aluminates termed clinker, which is mixed with gypsum (4 to 5 per cent by weight) and ground to a fine powder to form portland cement. By close control of the raw mix, the burning conditions and of the use of additives in the clinker-grinding procedure, finished cements displaying various properties can be produced.

Moderate Portland Cement and Low-Heat-of-Hydration Portland Cement, designed for use in concrete to be poured in large masses, such as in dam construction, are manufactured by several companies in Canada. Masonry cement (generic name) includes such proprietary names as Mortar Cement, Mortar Mix (unsanded), Mason's Cement, Brick Cement and Masonry Cement. The latter product produced by portland cement manufacturers, is a mixture of portland cement, finely ground high-calcium limestone (35 to 65 per cent by weight) and a plasticizer. The other products do not necessarily consist of portland cement and limestone, and may include a mixture of portland cement and hydrated lime and/or other plasticizers.

Portland cement used in Canada should conform to the specifications of CAN 3-A5-M83, published by the Canadian Standards Association (CSA). This standard covers the five main types of portland cement. Masonry cement produced in Canada should conform to the CAN 3-A8-M83. Blended hydraulic cements are covered by CAN 3-A362-M83. The cement types manufactured in Canada, but not covered by the CSA standards, generally meet the appropriate specifications of the American Society for Testing and Materials (ASTM).

OUTLOOK

Canada's economic recovery has lagged uncommonly far behind recovery in the United States since 1982. The construction industry in the United States became very active following the 1980-81 recession and demand for the materials of construction presented opportunities for Canadian producer-exporters of cement, clinker, gypsum and gypsum wallboard. Canadian business investment remained low and construction expenditures, particularly in engineering projects actually decreased. Housing starts dropped to 125,860 in 1982, the lowest number of starts since 1961, rebounded to 162,645 in 1983, dropped again in 1984 to 134,900 and rose to 165,826 in 1985. Housing starts in 1986 are expected to be 202,000. Residential, commercial and institutional building construction have been more active, accounting for steady but slow growth in the building construction sector as a whole. A few indicators provide a positive outlook for the building construction sector: housing starts are increasing, inflation is relatively low, and the unemployment rate is falling. However, direct spending on construction could be tempered by increased taxes on building materials and by government spending cuts. On a regional basis the construction outlook is fairly good in eastern Canada but less encouraging in the western region.

The Canadian Construction Association is predicting increases in the non-residential contract construction industry constant dollar expenditures of 4.5 per cent through 1986 to 1995 based upon the influences of the Western Accord and the May 1985 budget. The construction industry as a whole has expressed concern that Canada's large infrastructure network needs attention, leading to major renovation and upkeep projects similar to those begun on the United States highway system. Such a program would permit the construction industry and that portion of the mining industry which depends on it to plan five to ten years ahead with obvious benefits in efficiency, rather than to invest with short-term survival as the main incentive.

The cement industry in Canada is capable of meeting immediate demand and is also capable of expansion to meet even greater demand from domestic and foreign markets should opportunities be presented. The pattern of consumption of portland cement established during 1983-84 will likely persist for a few years or until the development of mega projects once again alters the current demand for cement. The attitude of the industry's principal foreign market, the United States, towards imported cement will have a great influence on the efficiency of the Canadian operations while demand from Canadian construction recovers.

Conservation of energy and raw materials within the cement industry is of worldwide concern and provides a theme around which major developments in the industry have taken place. Of particular note is the emphasis on blended cements and the utilization of slag, ash and other byproducts. Even greater additions to production capacities than those witnessed during the past few years will be needed to meet demand in many developing countries.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(cents per hundred pounds)		
CANADA					
29000-1	Portland and other hydraulic cement, nop; cement clinker	free	free	6	free
29005-1	White, nonstaining Portland cement	3.7	3.7	8	2.3
MFN Reductions under GATT (effective January 1 of year given)			1986	1987	
29005-1			3.7	3.7	
UNITED STATES (MFN)					
511.11	White, nonstaining Portland cement per 100 pounds including weight of container		1		
511.14	Other cement and cement clinker		free		
511.21	Hydraulic cement concrete		free		
			1986	1987	
			(% ad valorem)		
511.25	Other concrete mixed, per cubic yard		5.2	4.9	

Sources: The Customs Tariff, 1986, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated 1986, USITC Publication 1775; U.S. Federal Register Vol. 44, No. 241.

TABLE 1. CANADA, CEMENT PRODUCTION AND TRADE, 1984-86

	1984		1985		1986P	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Production[1]						
By province						
Ontario	3 654 153	256,084	4 092 753	283,677	3 965 000	282,189
Quebec	2 728 097	171,651	3 093 545	183,794	3 231 000	200,700
Alberta	989 619	120,071	1 142 852	148,881	934 000	124,951
British Columbia	939 354	69,939	988 498	74,818	1 013 000	78,740
Manitoba	335 988	34,192	342 963	35,725	431 000	46,104
Saskatchewan	..	18,852	..	19,237	..	20,007
Nova Scotia	..	24,252	..	21,079	..	20,449
New Brunswick	..	14,567	..	12,366	..	8,406
Newfoundland	..	7,675	..	8,779	..	9,300
Total	9 240 257	717,282	10 192 442	788,357	10 058 000	790,846
By type						
Portland	8 276 878	642,627	9 889 327	..	9 610 000	..
Masonry[2]	1 150 994	90,743	303 115	..	348 000	..
Total	9 427 872	733,370	10 192 442	788,357	10 058 000	790,846
					(Jan.-Sept.)	
Exports						
Portland cement						
United States	2 120 902	105,631	2 478 046	127,772	1 833 172	95,409
Cameroon	3 740	330	1 017	87	984	69
Other countries	5 469	687	6 636	497	2 192	142
Total	2 130 111	106,648	2 485 699	128,356	1 836 348	95,620
Prestressed concrete structures						
United States	..	12,884	..	26,036	..	30,798
Others	..		..	74	..	29
Total	..	13,131	..	26,100	..	30,827
Cement and concrete basic products						
United States	..	57,972	..	55,625	..	45,343
Other countries	..	1,714	..	351	..	283
Total	..	59,686	..	55,976	..	45,626
Imports						
Portland cement, standard						
United States	208 121	16,735	210 954	15,986	146 506	11,410
Other countries	757	66	2 814	152	30 862	1,072
Total	208 878	16,801	213 768	16,380	177 368	12,482
White cement						
United States	1 457	240	2 201	245	1 035	129
Japan	1 167	187	1 013	184	484	81
Other countries	249	31	915	118	1 470	145
Total	2 873	458	4 129	547	2 989	355
Aluminous cement						
United States	6 198	2,055	5 419	1,999	5 109	1,516
Other Countries	-	-	-	-	-	-
Total	6 198	2,055	5 419	1,999	5 109	1,516
Cement, nes						
United States	16 414	2,337	50 417	4,489	27 549	3,314
United Kingdom	369	81	3 751	828	2 358	630
Japan	80	11	386	59	317	330
West Germany	19	7	72	18	59	117
Italy	13	3	20	5	5	1
France	-	-	530	31	-	-
Netherlands	-	-	-	-	6	11
Other countries	-	-	2	1	-	-
Total	16 906	2,438	28 931	3,077	30 294	4,005
Total cement imports	236 114	21,841				
Cement and concrete basic products, nes						
United States	..	3,914	..	3,869	..	3,074
France	..	28	..	6	..	37
West Germany	..	26	..	148	..	103
United Kingdom	..	17	..	66	..	111
Belgium-Luxembourg	..	14	..	-	..	-
Other countries	..	1	..	96	..	125
Total	..	4,000	..	4,185	..	3,450
Cement clinker						
Spain	-	-	38 562	1,132	63 891	2,293
Greece	-	-	-	-	29 806	1,143
France	-	-	-	-	24 308	709
Belgium-Luxembourg	-	-	24 503	791	-	-
Venezuela	-	-	31 876	1,052	-	-
United States	119	4	-	-	85	3
Total	119	4	94 941	2,975	118 090	4,249

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Producers' shipments plus quantities used by producers. [2] Includes small amounts of other cement.

P Preliminary; .. Not available; - Nil; nes Not elsewhere specified.

TABLE 2. CEMENT PLANTS, APPROXIMATE ANNUAL GRINDING CAPACITY, END OF 1986

Company	Plant	Wet(W) Dry(D) Pre-heater(x) Precal-ciner(c)	Fuel (Coal Oil Gas)	No. of Kilns	Grinding Capacity	Clinker Capacity
					(000 tpy)	
Atlantic						
Canada Cement Lafarge Ltd.	Brookfield, N.S.	D	C,O	2	485	458
	Havelock, N.B.	D	C,O	2	315	300
North Star Cement Limited	Corner Brook, Nfld.	Dx	O	1	250	120
Atlantic Region Total				5	1 050	878
Quebec						
Canada Cement Lafarge Ltd.	St. Constant	D	O,G	2	955	902
Ciment Quebec Inc.	St. Basile	W,Dc	O	3	575	1 106
Miron Inc.	Montreal	D	O,G	2	1 000	840
St. Lawrence Cement Inc.	Beauport	W	C,O	2	550	598
(Independent Cement Inc.)	Joliette	D	C,O	4	1 000	976
Quebec Region Total				13	4 080	4 422
Ontario						
Canada Cement Lafarge Ltd.	Woodstock	W	C,G	2	535	505
	Bath	Dx	O,G	1	1 000	943
Federal White Cement	Woodstock	D	O	1	100	100
Lake Ontario Cement Limited	Picton	D,Dx	C,G	4	744	1 419
St. Lawrence Cement Inc.	Clarkson	W,Dc	C,O,G	3	2 400	1 700
St. Marys Cement Company	Bowmanville	W	C	2	790	600
	St. Marys	W,Dx	O,G	3	800	990
Ontario Region Total				16	6 270	6 257
Prairies						
Canada Cement Lafarge Ltd.	Fort Whyte, Man.	W	O,G	2	565	532
	Exshaw, Alta.	D,Dc	G	3	1 230	1 184
	Edmonton, Alta.				220	
Genstar Cement Limited	Winnipeg, Man.	W	O,G	1	325	310
	Regina, Sask.	D	O,C	1	375	214
	Edmonton, Alta.	W,Dc	G	4	2 040	1 186
Prairies Region Total				11	4 755	3 426
British Columbia						
Canada Cement Lafarge Ltd.	Kamloops	D	G	1	190	180
	Richmond	W	O,G	2	555	522
Genstar Cement Limited	Tilbury Island	Dx	O,G	1	1 000	855
B.C. Region Total				4	1 745	1 557
CANADA TOTAL (9 companies)				49	17 900	16 540

Source: Market and Economic Research Department, Portland Cement Association.

TABLE 3. CANADA, CEMENT PLANTS, KILNS AND CAPACITY UTILIZATION, 1977-86

	Clinker Producing Plants	Kilns	Approximate Cement Grinding Capacity[1]	Portland and Masonry Cement Production[2]	Clinker Exports[3]	Approximate Total Production[4]	Capacity Utilization
			(tpy)	(t)	(t)	(t)	(%)
1977	22	49	14 885 000	9 639 679	775 145	10 414 824	72
1978	24	51	15 985 000	10 558 279	1 077 274	11 635 553	72
1979	24	51	15 985 000	11 765 248	1 530 537	13 295 785	83
1980	23	47	16 363 000	10 274 000	726 087	11 000 087	67
1981	23	48	16 771 000	10 145 000	524 006	10 669 006	64
1982	23	48	16 771 000	8 418 000	290 329	8 708 329	50
1983	23	49	17 900 000	7 870 878	404 793	8 275 671	46
1984	23	49	17 900 000	9 387 466	440 297	9 827 763	55
1985	23	49	17 900 000	10 192 444	676 596	10 869 040	61
1986	23	49	17 900 000	10 058 000P	950 000^e	11 008 000	62

Sources: Statistics Canada, U.S. Bureau of Mines, Portland Cement Association (PCA).

[1] Includes two plants that grind only. [2] Producers' shipments and amounts used by producers. [3] Imports to United States from Canada. [4] Cement shipments plus clinker exports.

^{e} Estimated; P Preliminary.

TABLE 4. CANADA, HOUSE CONSTRUCTION, BY PROVINCE, 1984 AND 1985

	Starts			Completions			Under Construction		
	1984	1985	% Diff.	1984	1985	% Diff.	1984	1985	% Diff.
Newfoundland	2,720	2,854	4.9	3,134	1,852	-40.9	3,000	3,348	11.6
Prince Edward Island	643	788	22.5	581	757	30.3	379	420	10.8
Nova Scotia	4,598	6,923	50.6	5,082	5,748	13.1	2,466	3,474	40.9
New Brunswick	2,873	4,142	44.2	3,923	3,224	-17.8	1,242	2,137	72.1
Total (Atlantic Provinces)	10,834	14,707	35.7	12,720	11,581	-8.9	7,087	9,379	32.3
Quebec	41,902	48,031	14.6	43,410	41,577	-4.2	16,309	21,270	30.4
Ontario	48,171	64,871	34.7	54,642	50,590	-7.4	23,529	36,761	56.2
Manitoba	5,308	6,557	23.5	5,865	5,081	-13.4	2,474	3,817	54.3
Saskatchewan	5,221	5,354	2.5	5,722	5,653	-1.2	3,187	2,866	-10.1
Alberta	7,295	8,337	14.3	12,057	7,517	-37.6	2,943	3,518	21.7
Total (Prairie Provinces)	17,824	20,248	13.6	23,644	18,251	-22.8	8,604	10,201	18.6
British Columbia	16,169	17,969	11.1	18,596	17,107	-8.0	8,370	8,755	4.6
Total Canada	134,900	165,826	22.9	153,012	139,106	-9.1	63,899	86,366	35.2

Source: Canada Mortgage and Housing Corporation.

TABLE 5. CANADA, VALUE OF CONSTRUCTION[1] BY TYPE, 1984-86

	1984	1985	1986
		($ millions)	
Building Construction			
Residential	16,647	18,750	21,177
Industrial	2,708	3,216	3,395
Commercial	7,129	8,201	8,563
Institutional	2,924	3,143	3,404
Other building	2,003	2,025	2,010
Total	31,411	35,335	38,549
Engineering Construction			
Marine	474	484	483
Highways, airport runways	4,276	4,648	4,514
Waterworks, sewage systems	2,170	2,148	2,237
Dams, irrigation	272	303	324
Electric power	3,664	3,494	3,491
Railway, telephones	2,724	2,728	2,677
Gas and oil facilities	8,552	9,178	8,580
Other engineering	3,031	3,131	2,967
Total	25,163	26,114	25,273
Total construction	56,574	61,449	63,822

Source: Statistics Canada.

[1] Actual expenditures 1984, preliminary actual 1985, intentions 1986.

TABLE 6. CANADA, VALUE OF CONSTRUCTION[1] BY PROVINCE, 1984-86

	1984			1985			1986		
	Building Construction	Engineering Construction	Total	Building Construction	Engineering Construction	Total	Building Construction	Engineering Construction	Total
					($000)				
Newfoundland	512,020	1,103,521	1,615,541	559,926	1,046,395	1,606,321	648,726	777,677	1,426,403
Nova Scotia	947,048	1,157,778	2,104,826	1,145,364	1,170,295	2,315,659	1,142,984	822,811	1,965,795
New Brunswick	735,008	465,074	1,200,082	795,548	483,805	1,279,353	849,490	413,322	1,262,812
Prince Edward Island	117,220	74,162	191,382	145,928	68,638	214,566	149,321	80,269	229,590
Quebec	7,714,033	4,065,606	11,779,639	8,773,335	3,812,658	12,585,993	9,271,680	3,796,029	13,067,709
Ontario	11,409,974	5,359,605	16,769,579	13,572,920	5,378,915	18,951,835	15,583,901	5,394,357	20,978,258
Manitoba	1,151,749	721,257	1,873,006	1,320,926	793,268	2,114,194	1,416,651	973,561	2,390,212
Saskatchewan	1,227,024	1,385,015	2,612,039	1,258,206	1,656,228	2,914,434	1,293,703	1,553,938	2,847,641
Alberta	3,299,989	6,230,580	9,530,569	3,435,866	7,273,787	10,709,653	3,876,910	7,947,462	11,824,372
British Columbia, Yukon and Northwest Territories	4,297,525	4,600,290	8,897,815	4,327,013	4,430,416	8,757,429	4,316,058	3,513,411	7,829,469
Canada	31,411,590	25,162,888	56,574,478	35,335,032	26,114,405	61,449,437	38,549,424	25,272,837	63,822,261

Source: Statistics Canada.

[1] Actual expenditures 1984, preliminary actual 1985, intentions 1986.

Clays and Clay Products

M. PRUD'HOMME

Clays are a complex group of industrial minerals, each generally characterized by different mineralogy, occurrence and uses. All are natural, earthy, fine-grained minerals of secondary origin, composed mainly of a group of hydrous aluminum phyllosilicates and may contain iron, alkalis and alkaline earths. The clay minerals, formed by the chemical weathering or alteration of aluminous minerals are generally classified into four major groups based on detailed chemistry and crystalline structure - the kaolinite group, the smectite group (montmorillonite group of some usages), the clay-mica group and the chlorite group. Clay deposits suitable for the manufacture of ceramic products may include non-clay minerals such as quartz, calcite, dolomite, feldspar, gypsum, iron-bearing minerals and organic matter. The non-clay minerals may or may not be deleterious, depending upon individual amounts present and on the particular application for which the clay is intended.

The commercial value of clays, and of shales that are similar in composition to clays, depends mainly on their physical properties - plasticity, strength, shrinkage, vitrification range and refractoriness, fired colour, porosity and absorption - as well as their economic value which is based on production and transportation costs, level of competition and potential for substitution.

Brick manufacturing included in the structural clay products category accounts for 84 per cent of the total value of output from clay products manufacturers using material from domestic sources, while drain tile and flue lining account for 1.9 per cent and 4.5 per cent respectively.

USES, TYPE AND LOCATION OF CANADIAN DEPOSITS

Common Clays and Shale. Common clays and shales are the principal raw materials available from Canadian deposits for the manufacture of structural clay products. They are found in all parts of Canada, but deposits having excellent drying and firing properties are generally scarce and new deposits are continually being sought.

The clay minerals in common clays and shales are chiefly illitic or chloritic. The material is sufficiently plastic to permit molding and vitrification at low temperature. Suitable common clays and shales are utilized in the manufacture of structural clay products such as common brick, facing brick, structural tile, partition tile, conduit tile and drain tile. There are no specific recognized grades of common clay and shale. Specifications are usually based upon the physical and chemical tests of manufactured products. The raw materials utilized in the structural clay industry usually contain up to 35 per cent quartz. If the quartz, together with other nonplastic materials, exceeds this percentage, the plasticity of the clay is reduced and the quality of the ware is lowered. If calcite or dolomite is present in sufficient quantities, the clay will fire buff and the fired strength and density will be adversely affected.

Most of the surface deposits of common clays in Canada are the result of continental glaciation and subsequent stream transport. Such Pleistocene deposits are of interest to the ceramic industry and include stoneless marine and lake sediments, reworked glacial till, interglacial clays and floodplain clays.

In eastern Canada, shales are also consumed in large quantities for manufacturing cement near Corner Brook in western Newfoundland, and at Havelock in Kings County, New Brunswick. Common clay from glacial drift is used in Ontario as a source of silica and alumina in the local manufacture of grey portland cement at Woodstock and St. Mary's. In Manitoba, shales and clays from glacial Lake Agassiz are extracted to produce lightweight aggregates. In Alberta, local glacial clays from Regina are used for manufacturing cement, lightweight aggregates and mineral wool insulation. In British

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Columbia, altered volcanic ash is extracted at Barnhartvale for cement, and in Quesnel mainly for use in manufacture of refractory materials. Common clay is also extracted from Sumas Mountain near Abbotsford to produce flue lining, drain pipe, bricks and blocks.

During 1986, the Canada Centre for Mineral and Energy Technology (CANMET) carried out some work on the characterization of clays and shales for various product applications. The work involves material preparation, measurement of plasticity of clay-water mixtures, optimization of extrusion and drying characteristics, test firings and determination of critical properties such as shrinkage and porosity of products. In cooperation with the Ministry of Indian and Northern Affairs, a clay from northern Ontario is currently being characterized for product applications. Similar work has been carried out for several pottery and brick manufacturers.

As a result of the concerns of the Clay Brick Manufacturers Association of Canada, and under a CANMET project related to energy conservation in mineral processing, work is also being carried out by external contractors on the containment or reduction of fluoride emissions from brick kilns.

For further information on kaolin and clay products R&D, contacts at CANMET are: P. Andrews and A.K. Kuriakose (telephone 613-992-8794).

China Clay (Kaolin). China clay is a white clay composed mainly of kaolinitic minerals formed from weathered igneous rocks. Some deposits occur in sedimentary rocks as tabular lenses and discontinuous beds or in rocks that have been hydrothermally altered. Commercial china clays are beneficiated to improve their whiteness when used as fillers and their whitefiring characteristics when used in ceramics.

China clay is used primarily as a filler and coating material in the paper industry, a raw material in ceramic products, and a filler in rubber and in other products. In the ceramic industry china clay is used as a refractory raw material. In prepared whiteware bodies such as wall tile, sanitaryware, dinnerware, pottery and electrical porcelain, quantities of nepheline syenite, silica, feldspar and talc are used as well.

Several occurrences of kaolin in Canada have attracted attention. In British Columbia, a deposit of clay similar to a secondary kaolin occurs along the Fraser River near Prince George. In Saskatchewan, known deposits of sandy kaolinized clay with off-white colored fines occur near Fir Mountain, Flintoft, Knollys, and Wood Mountain. Ekaton Industries Inc. of Calgary acquired the rights of 45,000 acres of land in southern Saskatchewan to explore for kaolin in 1984. Reserves of kaolinized sand have been estimated at over 100 million t in the Wood Mountain area, and over 160 million t in the Eastend area. The deposits are composed of equal parts of silica sand and kaolin. During 1986, research and development work has been carried out at the Saskatchewan Research Council, the Colorado School of Mines Research Institute and at Miles Laboratory in Colorado. Detailed processing and engineering studies were conducted on Ekaton kaolin, including a study for a pilot plant to process 90 t kaolin. A consulting firm from Georgia completed a prefeasibility study for a 145 000 tpy kaolin mine and processing plant. A decision on construction will be made during the spring of 1987 with production expected to begin in early-1988. Kaolin products will be used as a filler in the pulp and paper industry of western Canada and the northwestern United States. Ekaton Industries Inc. is looking for a partner to set up a joint venture for the kaolin project in Saskatchewan.

In Manitoba, various kaolinitic-rock deposits have been reported at Arborg, on Deer Island (Punk Island) and Black Island on Lake Winnipeg, and in the northwest at Cross Lake and Pine River; the Swan River Formation has also been investigated as a potential source of kaolin.

In Ontario, extensive deposits of kaolin-silica sand mixtures occur along the Missinaibi and the Mattagami rivers. Carlson Mines Ltd. of Toronto established the James Bay Kaolin Company, as a subsidiary to develop a kaolin-silica sand mine near Smooth Rock Falls in Ontario. Production facilities are expected to be constructed by mid-1988. During 1986, Kilborn Limited was commissioned to prepare a final feasibility study for a 2 750 tpd open-pit mine and processing plant. Carlson Mines Ltd. has also exercised an option to purchase a 50 per cent interest in nine claims in the Moose River Basin. Proven reserves have been estimated at 57 million t of unconsolidated materials to a depth of 34 m. A $7 million plant will be started in 1987, providing 30 jobs.

Kaolin of Canada Inc. completed geological and geophysical work on its property in the Kipling Township, Ontario.

In Quebec, kaolin deposits have been actively mined in the past as a coproduct of a silica operation, near St-Rémi-d'Amherst, in Papineau County. Occurrences near Château-Richer in Montmorency County and Point-Comfort in Gatineau County have been studied as potential sources of kaolin for alumina, suitable for aluminous cement and refractories.

Ball Clay. Ball clay is defined as a fine-grained, highly plastic and mainly kaolinitic sedimentary clay. Natural colours range from white to brown, blue, grey and black, usually related to carbonaceous material. Fired colours may be white to offwhite. They are extremely refractory materials and have less alumina and more silica than kaolin. Ball clays occur in beds or lenticular units characterized by complex variation, both vertically and laterally.

Ball clays occurring in Canada are mineralogically similar to high-grade, plastic fire clay and are composed principally of fine-particle kaolinite, quartz and mica. These clays are known to occur in the Whitemud and the Ravenscrag Formations - Willowbunch Member - of southern Saskatchewan. Clay production takes place near Claybank, Eastend, Estevan, Flintoft, Readlyn, Rockglen, Willowbunch and Wood Mountain.

Fire Clay (Refractory Clay). Fire clay is a detrital clay mainly composed of kaolinite with a high content of alumina and silica. It usually occurs in sedimentary rocks as lenticular bodies. These clays may range in plasticity from essentially that of ball clay to nonplastic varieties such as flint clay. They are formed by alteration of aluminous sediments deposited in a swampy environment or following transportation and concentration of clayey material.

Fire clay is used in the manufacture of products requiring high resistance to heat such as fire brick, insulating brick and refractory mortar. The refractory suitability is determined by the pyrometric cone equivalent (PCE) test. Canadian fire clays are used principally for the manufacture of medium- and high-duty fire brick and refractory specialties.

Various grades of good-quality fire clay occur in the Whitemud Formation in southern Saskatchewan and on Sumas Mountain in British Columbia. Fire clay, associated with lignite as well as with kaolin-silica sand mixtures, occurs in the James Bay watershed of northern Ontario along the Missinaibi, Abitibi, Moose and Mattagami rivers. At Shubenacadie, Nova Scotia, some seams of clay are sufficiently refractory for medium-duty fire clay. Clay from Musquodoboit, Nova Scotia, has been used by some foundries in the Atlantic provinces, and the properties and extent of this clay were investigated by the Nova Scotia Department of Mines.

Stoneware Clay. Stoneware clays are intermediary between low-grade common clays and the high-grade kaolinitic clays. They are typically a mixture of kaolinitic clay minerals and micaceous clay minerals. Stoneware clays must be capable of being fully vitrified at a relatively low temperature.

Stoneware clays are used extensively in the manufacture of sewer pipe, flue liners, and facing brick. They are widely used by amateur and studio potters.

The principal source of stoneware clay in Canada is the Whitemud Formation in southern Saskatchewan and southeastern Alberta. Stoneware clays also occur near Abbotsford on Sumas Mountain, at Chimney Creek Bridge, Quesnel and Williams Lake, British Columbia; near Swan River in Manitoba; and in Nova Scotia, at Musquodoboit and at Shubenacadie where it is used principally for manufacture of buff-facing bricks.

Bentonite and Fuller's Earth. Bentonite consists primarily of montmorillonite clay, and is formed from volcanic ash, tuff or glass, other igneous rocks, or from rocks of sedimentary origin. Sodium bentonite has strong swelling properties and possesses a high dry-bonding strength. Calcium bentonite of the non-swelling type, exhibits adsorptive characteristics. Fuller's earth contains mainly smectite-group clay minerals and is very similar to non-swelling bentonite. It is formed by alteration of volcanic ash or by direct chemical precipitation of montmorillonite in shallow marine basins. Fuller's earth is characterized by absorptive properties, catalytic action, bonding power and cation-exchange capacities.

Drilling Mud and Activated Clays. Drilling mud contains about 10 per cent swelling bentonite. Synthetic bentonites may also be used for special muds. The swelling properties of a bentonite used as a drilling mud may be improved by adding soda ash in a drying process to substitute calcium cations with sodium cations. Activated clays are non-swelling bentonites that are acid-leached to remove impurities and to increase the reactive surface and bleaching power. They are used for decolouring mineral oils and as catalysts.

Bentonite, fuller's earth and activated clays are covered in sections of a separate mineral review.

CANADIAN INDUSTRY

Clays. Production of clays is captive to their use in lightweight aggregates, cement and mineral wool insulation, which consumed mainly common clay, stoneware clay and ball clay. In 1986, there was no commercial kaolin operation in Canada, and all requirements were supplied by imports mainly from Georgia and South Carolina, U.S.A. On a nine month basis in 1986, imports of kaolin rose by 12.3 per cent to 227 505 t over the same period in 1985. The average unit value of imports increased by 6 per cent to $142 per t. Imports were mainly in Ontario (57 per cent), Quebec (27 per cent), British Columbia (5 per cent) and Manitoba (4 per cent).

In Canada, imported kaolin is used mainly in the pulp and paper industry which accounts for around 80 per cent of total consumption, followed by ceramics (4.5 per cent), rubber (3.7 per cent) and paint and varnish (3 per cent). Reported consumption of kaolin in 1985 grew by 9 per cent largely due to higher consumption in the pulp and paper industry which is concentrated in Ontario (50 per cent) and Quebec (45 per cent).

During 1986, imports of fire clay dropped significantly by 38 per cent to 21 140 t. Fire clay is imported mainly from the United States (98 per cent) and United Kingdom (2 per cent) into Ontario (85.3 per cent) and Quebec (9.5 per cent). The average unit value for imported fire clay increased by 39 per cent to $99 per t. All requirements for clays in western Canada are supplied by the United States. Fire clay is used mainly in refractories (30 per cent) and foundries (20 per cent).

Clay products. Clay products include structural materials – such as bricks and tiles – sewer pipes, flue linings, drain tiles, earthenwares, tablewares, sanitaryware and pottery. In 1986, some 40 companies accounted for about 95 per cent of the total value of shipments of clay products based on both domestic and imported clays. The value of shipments of clay products from domestic clays rose significantly by 30 per cent to $180.4 million due to a higher level of construction in Quebec (67 per cent), Ontario (24 per cent), British Columbia (47 per cent) and Alberta (30 per cent). Shipments of building and face bricks in Canada increased by 18 per cent in 1986. Higher levels of production were reported in residential construction, particularly in Ontario and Quebec with respective increases of 21.5 and 24.3 per cent. Clay brick producers in western Canada were less fortunate as brick shipments increased by only 10 per cent; in British Columbia shipments dropped by 20 per cent, mainly due to reduced activity in the commercial construction.

The residential construction sector accounted for more than 80 per cent of total shipments of brick in the Atlantic provinces, Quebec, Ontario and British Columbia but for only 50 per cent in the Prairies. Clay brick producers in central Canada and the Atlantic provinces operated at full capacity in 1986, while they averaged 60 per cent in western Canada. Ontario, the major market for brick, accounted for 72 per cent of total brick shipments, followed by Quebec (17 per cent), Western Provinces (7 per cent) and Atlantic Provinces (5 per cent).

For the first nine months in 1986, shipments of imported brick and block rose by 23.4 per cent to $14 million compared to the same period in 1985. The United States is the leading supplier with 86 per cent of total imports of bricks, blocks and tiles. Imported bricks were shipped mainly to Ontario (82 per cent) and British Columbia (13 per cent). The average import price in 1986 was about $153 per thousand bricks, a significant increase of 16 per cent over 1985.

The value of shipments of imported ceramic tiles increased by 53 per cent for the first nine months of 1986. Italy was the principal supplier of ceramic tiles accounting for 54 per cent of the total value of imports followed by Spain (12 per cent) and Japan (11 per cent). Imports were mainly in Ontario (49 per cent).

During 1986, Brampton Brick Limited of Brampton, Ontario, acquired Citadel Brick Ltd. of Beauport, Quebec, the major brick manufacturer in eastern Quebec with an annual output of 50 million units.

Canada Brick Co., division of Jannock Limited of Streetsville, Ontario, announced the construction of a new facebrick plant in Burlington. The construction of a 75 million brick per year manufacturing facility started in 1986 and will be completed in the summer of 1987 at a cost of $25 million, creating 35 permanent jobs. The company has contracted Swindell Dresser Corporation for engineering and construction. The plant will be using the low firing concept and will have the largest capacity for brick in North America when the second phase of construction is completed in two years, doubling the capacity of production at a cost of $10 million. Most of the new production will be used in Ontario but the United States represents a potential market for exports.

Maritime Clay Company of Oakville, Ontario, purchased land in Middle Musquodoboit, Nova Scotia, for the construction of a $770,000 manufacturing plant. The company already has equipment in place for using clay from the Musquodoboit Valley to manufacture ceramic dinnerware.

Refractories. Refractories are produced in Canada by 16 major manufacturers of basic and alumina-silica products. Special refractories such as refractory mineral wool and carbon-compound mortars are also produced. In 1985, imports of refractories amounted to $156 million, an increase of 10.6 per cent over 1984. On a nine month basis in 1986, the value of imported refractories remained steady at close to $116 million. Magnesia refractory brick and shapes accounted for 24 per cent of the total value of imported refractories, followed by alumina brick and shapes (18.3 per cent). Refractory bricks were imported mainly from the United States (90 per cent) into Ontario (85.7 per cent) and Quebec (13.3 per cent). The average unit values for imports of alumina brick and magnesite brick were respectively $858 and $1,206 per t in 1986. Exports of refractory bricks and shapes dropped by 17.7 per cent to $15 million on a nine-month basis in 1986.

WORLD REVIEW

In 1985, the world production of kaolin was estimated at 21 190 000 t. The United States was the major producer with 34 per cent of total world production, followed by the United Kingdom (14 per cent) and the U.S.S.R. (13 per cent). Ball clay production is dominated by West Germany, the United States and the United Kingdom. While plastic refractory clay is produced widely, fire flint clay production is restricted to Australia, Austria, China, France, Hungary, South Africa, United States and U.S.S.R.

Australia

Australia China Clays started trial production of kaolin at the pilot plant near Gulgong, New South Wales. Products should be suitable for the porcelain and tableware industries in South East Asia. Construction of a 25 000 tpy plant is nearly completed. An expansion is planned to double the initial capacity in 1987.

Comalco Limited inaugurated a kaolin mining and processing operation at its Waipa bauxite mine in North Queensland with an initial capacity of 100 000 tpy. Indicated reserves are estimated at 23.5 million t. The kaolin products can be used as a coating pigment in paper for markets in the Pacific Basin. Comalco Japan KK has been appointed agent in Japan.

Finland

Lohja Paperi Oy has been granted permission from the Ministry of Environment to mine kaolin at the Paljak nature parklands in northern Finland. The refined kaolin will be used in the Finnish paper industry.

Sri Lanka

Deposits of high grade kaolin have been identified near Metiyagoda by the Geological Survey Department. Reserves have been estimated at 440 000 t grading 70 per cent kaolinite.

Tanzania

Pugu Kaolin Co. received financial assistance from the African Development Bank to carry out a major expansion of the open-pit kaolin mine and beneficiation plant. Proven reserves have been estimated at 11.2 million t.

United States

In the United States, the production of kaolin in 1985 declined by 2 per cent to

7 070 000 t. Georgia accounted for 81.4 per cent of total production followed by South Carolina (11 per cent). The average unit value decreased by 4 per cent to $US 76.4 per short ton. Kaolin accounted for 17 per cent of total clay production and 59 per cent of total value. In Georgia, 85 producers were in operation while 22 were active in South Carolina. Waterwashed kaolin accounted for 48 per cent of total kaolin production followed by airfloat products (16 per cent) and calcined kaolin (14 per cent). Kaolin was mainly used in paper coating (35 per cent), paper filling (18 per cent), ceramics (9 per cent), refractories (8 per cent) and rubber (5 per cent). In 1985, exports of kaolin amounted to 1.25 million t, a 2 per cent decline from 1984, and were shipped mainly to Japan (32 per cent), Canada (20 per cent), the Netherlands (11 per cent) and Italy (8 per cent).

Albion Kaolin Co., owned by United Catalysts Inc., has introduced a statistical quality control system at its Hephzibah kaolin operation in Georgia. This system involves product specifications analysis during processing and prior to shipment. Such controls ensure quality of shipments from the supplier, product consistency and eventually will permit to control processing costs. Albion Kaolin also announced an expansion at its slurry facilities in Hephzibah, Georgia. The expansion includes the installation of a high-speed mixer and vibrating screen. The slurry is used to manufacture refractories, ceramics and fiberglass.

Anglo-American Clay Limited, a subsidiary of ECC America Inc. continued to work on its expansion program at the Sandersville plant in Georgia. The expansion will raise production capacity by 65 per cent for opacifying pigment and by 25 per cent the drying capacity for high-brightness coating clay grades.

Englehard Corporation of Seneca, South Carolina, began the construction of a $25 million facility to produce custom catalysts used in industrial and pharmaceutical products.

J.M. Huber Corp. has instituted the use of a superconducting magnet for the separation system at its wet processing plant near Wrens in Georgia. The unit which costs $2.1 million is used to remove micron-sized iron-bearing impurities with lower energy consumption and improved processing speed.

Union Carbide Corporation acquired a 50 000 tpy plant in Savannah, Georgia, that manufactures kaolin-based cracking catalysts.

OUTLOOK

Clays and clay products are materials characterized mainly by high bulk, low unit value and a sensitivity to transportation costs. Therefore, they are very sensitive to fluctuations in the general economic climate. Structural clay products are mainly used in the construction sub-sectors such as residential and non-residential building.

The restructuring of the North American refractories industry reflects the rationalization occurring in the U.S. refractory industry and spreading into Canada. Such changes are necessary because of technological improvements in the industry and because of reduced consumption in the metallurgy sector. The U.S. Bureau of Mines expects demand for refractory clays to grow at an average annual rate of 4.9 per cent for the period 1983-2000.

In the next decade, the refractory industry in North America will undergo major changes as it will digest the overcapacity which is currently estimated at between 35 and 50 per cent. Rationalization and consolidation will result in more efficient manufacturing. The North American refractory industry will follow the specialization and diversification trends established in Europe.

In 1987, the consumption of refractories is forecast to decline slightly. Demand for refractories has been decreasing since 1980 because of lower steel production, the traditional but highly competitive market for refractories. The strong decline in refractories shipment over most of the current decade is also resulting from improvements in the performance of refractories which last longer. The increasing usage of water-cooled panels in electric-arc furnaces and hot-metal pre-treatments also reduces the consumption of refractories. The usage of low-grade fire clay and siliceous materials is forecast to decline while refractories made of fired dolomite, magnesia-chrome and magnesia-carbon will be used for more severe operating conditions. Flint clay refractories will be replaced by higher alumina materials with greater performance in ladle linings in particular.

Traditional markets are likely to assume less importance as refractories producers explore new markets in metal casing, nonferrous metals, chemicals, ceramics and mineral processing. The field of advanced ceramics is also seen as the new challenge for refractories.

Canada is currently dependent on imports, mainly from the United States for its supplies of china clay. However, developments in Ontario and Saskatchewan are being undertaken in anticipation of growing demand from the paper industry. In the fine and coated papers sector demand for kaolin will continue to be strong. Shipments of fine paper rose by 12 per cent in 1986 and are expected to increase by 10 per cent in 1987.

Kaolin is the dominant pigment used in the North American paper industry which uses the acid-wet end system. In the 1970s, the paper industry in North America started to convert the production process to the neutral/alkaline system. Kaolin has been tested and found adequately compatible with the neutral/alkaline system, even if its whiteness is not equivalent to that of calcium carbonate. Nevertheless, it is expected that kaolin will continue to be the major pigment used in the paper industry although the use of calcium carbonate will likely grow at a higher rate.

PRICE QUOTATIONS FOR BALL CLAY AND KAOLIN

Chemical Marketing Reporter, December 1986

	$US per short ton
Ball clay, f.o.b. Tennessee	
Airfloated, bags, carload	49.00
Crushed, moisture repellent, bulk carload	24.00
Kaolin, f.o.b. Georgia	
Dry-ground, airfloated, soft	60.00
NF powdered, colloidal, 50 lb bags, 5,000 lb lots	480.00
Waterwashed, fully calcined, bags, carload	255.00
Waterwashed, uncalcined, delaminated paint grade, 1 micron average	182.00
Uncalcined, bulk, carload	
No. 1 coating	94.00
No. 2 coating	75.00
No. 3 coating	73.00
No. 4 coating	70.00
filler, general purpose	58.00

Industrial Minerals, December 1986 quotation (£1.00 = $US 1.40-1.60)

	£ per tonne
Ball clay, f.o.b. works	
Air dried, shredded, bulk	15-40
Refined, noodled, bulk	35-40
Pulverized, air floated, bagged	50-80
Kaolin, refined, bulk, f.o.b. works	
Coating clays	75-120
Filler clays	40-60
Pottery clays	25-65

f.o.b. Free on board.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
CANADA					
29500-1	Clays, including china clay, fire clay and pipe clay not further manufactured than ground	free	free	free	free
29525-1	China clay	free	free	25	free

UNITED STATES (MFN)		(¢ per long ton)	
521.41	China clay or kaolin	33.0	
521.81	Other clays, not beneficiated	free	
521.84	Other clays, wholly or partly beneficiated	50.0	
		1986	1987
		(¢ per long ton)	
521.71	Common blue clay and other ball clays, not beneficiated	38.5	38.0
521.74	Common blue clay and other ball clays wholly or partly beneficiated	78.0	77.0

Sources: The Customs Tariff, 1986, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated (1986), USITC Publication 1775, U.S. Federal Register.
Note: In addition to the above tariffs various duties are in existence on manufactured clay products, viz., brick, pottery, artware, etc.

TABLE 1. CANADA, VALUE OF PRODUCTION OF CLAYS AND CLAY PRODUCTS FROM DOMESTIC SOURCES, 1984-86

	1984	1985P	1986e
		($000)	
Production from domestic sources, by provinces			
Newfoundland	1,546	1,340	1,480
Nova Scotia	6,430	7,070	7,730
New Brunswick	3,313	4,150	3,350
Quebec	20,945	19,130	31,780
Ontario	83,461	89,130	110,410
Manitoba	2,156	2,160	2,480
Saskatchewan	3,561	3,810	4,060
Alberta	8,153	7,830	10,160
British Columbia	7,230	3,620	8,900
Total	136,795	138,240	180,350
Production[1] from domestic sources, by products			
Brick - soft and stiff mud process and dry press	113,539	116,120	153,300
Drain tile	3,283	2,770	3,250
Flue linings	6,292	6,220	8,110
Other products[2]	9,851	8,850	10,820
Small establishments not reporting detail	3,830	4,280	4,870
Total	136,795	138,240	180,350

Source: Statistics Canada.

[1] Producers' shipments. Distribution estimated by Energy, Mines and Resources Canada.

[2] Including also sewer pipe and all potteries.

P Preliminary; e Estimated.

TABLE 2. CANADA, IMPORTS AND EXPORTS OF CLAYS, CLAY PRODUCTS, CERAMIC PRODUCTS AND REFRACTORIES, 1984-86

	1984		1985		(Jan.-Sept.) 1986P	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Imports						
Clays						
China clay, ground or unground	253 080	32,181	271 473	36,528	227 505	32,268
Fire clay, ground or unground	43 744	3,236	44 195	3,248	21 139	2,081
Clays, ground or unground nes	106 661	8,151	145 874	11,571	124 591	9,903
Bentonite	337 054	15,307	346 092	18,110	215 399	10,981
Fuller's Earth	4 152	525	4 965	561	3 867	324
Drilling mud	4 326	2,697	7 111	5,135	3 083	2,077
Clays and earth, activated	12 669	10,307	12 938	13,279	9 717	8,856
Subtotal, clays	761 686	72,404	832 648	88,432	605 301	66,490
Clay Products	(M)		(M)		(M)	
Brick-building, glazed	2 307	385	6 639	629	2 697	431
Brick-building, nes	31 228	5,492	67 245	8,875	62 525	9,564
Building blocks and hollow tiles	..	952	..	1,532	..	1,279
Brick acid-proof	..	67	..	30	..	49
Clay bricks, blocks and tiles, nes	..	4,673	..	4,163	..	2,658
Ceramic tiles	(m^2)		(m^2)		(m^2)	
under 2 1/2" x 2 1/2"	610 775	4,872	407 216	3,095	194 678	1,652
over 2 1/2" x 2 1/2"	9 202 855	60,724	8 748 544	58,972	8 371 604	65,537
Subtotal, bricks, blocks, tiles	..	77,165	..	77,296	..	81,170
Ceramic Products						
Tableware, ceramics	..	104,426	..	111,829	..	102,249
Sanitaryware	..	118	..	133	..	306
Artware	..	30,598	..	33,467	..	28,864
Porcelain, electric insulators	..	28,786	..	29,332	..	24,251
Chemical stoneware, exc. laboratory	..	1,103	..	1,958		1,969
Pottery settings and firing supplies	..	507	..	757	..	608
Pottery basic products, nes	..	2,852	..	6,281	..	4,275
Clay end-products, nes	..	1,687	..	1,320		1,048
Subtotal, ceramics	..	170,077	..	183,119	..	163,570
Refractories						
Fire brick and shapes						
Alumina	24 750	20,682	27 987	23,628	15 998	13,740
Chrome	1 539	1,848	219	356	218	382
Magnesite	21 592	25,841	25 047	28,741	15 449	18,578
Silica	3 918	3,292	1 958	3,299	1 485	1,809
Nes	124 968	50,927	111 975	52,439	84 203	40,478
Refractory cements and mortars	..	17,011	..	19,936	..	14,584
Plastic fire brick and ramming mixture	..	1,272	..	2,173	..	1,701
Crude refractory materials, nes	9 115	1,969	12 182	2,955	6 801	1,440
Grog (refractory scrap)	5 089	585	4 105	534	5 210	554
Foundry facings	..	2,266	..	2,403	..	1,968
Refractories, nes	..	15,240	..	19,913	..	21,420
Subtotal, refractories	..	140,933	..	156,377	..	116,654
Total clays, clay products, ceramics, and refractories	..	460,579	..	534,459	..	427,884
Imports by main countries						
United States	..	234,650	..	263,388	..	195,267
United Kingdom	..	51,965	..	60,483	..	60,257
Japan	..	56,575	..	64,526	..	55,329
Italy	..	35,128	..	35,850	..	40,267
West Germany	..	17,808	..	22,869	..	17,392
Spain	..	11,561	..	9,103	..	9,309
South Korea	..	5,387	..	4,843	..	7,484
Brasil	..	3,945	..	4,501	..	7,271
Taiwan	..	8,785	..	8,822	..	7,172
People's Republic of China	..	4,491	..	5,471	..	4,956
France	..	5,115	..	9,464	..	4,096
Greece	..	5,282	..	3,780	..	3,945
Hong Kong	..	2,865	..	1,657	..	1,031
Other	..	17,023	..	10,467	..	14,108
Total	..	460,579	..	505,224	..	427,884
Exports						
Clays, ground and unground	646	150	5 350	2,792	1 303	327
Clay products	(M)		(M)		(M)	
Building brick, clay	2 330	619	1 848	651	2 320	499
Clay bricks, blocks, tiles, nes	..	1,890	..	1,850	..	3,770
Subtotal, bricks, blocks, tiles	..	2,659	..	5,293	..	4,596
High-tension insulators and fittings	..	4,208	..	4,674	..	5,300
Tableware, nes	..	7,942	..	7,068	..	11,880
Subtotal, porcelain, tableware	..	12,150	..	11,742	..	17,180
Refractories						
Fire brick and shapes	38 005	22,019	38 171	23,763	27 444	15,566
Crude refractory materials	579 488	2,428	534 579	3,416	497 225	3,111
Refractory nes	..	31,587	..	34,040	..	30,758
Subtotal refractories	..	56,034	..	61,219	..	49,435
Total clays, clay products and refractories	..	70,843	..	78,254	..	71,211
Exports by main countries						
United States	..	54,153	..	55,559	..	61,855
South Africa	..	1,408	..	623	..	1,150
Cuba	..	2,165	..	3,530	..	1,084
Dominican Republic	..	1,443	..	2,204	..	766
Other countries	..	11,674	..	16,338	..	6,356
Total	..	70,843	..	78,254	..	71,211

Source: Statistics Canada.
P Preliminary; .. Not available; nes Not elsewhere specified; M = Thousands; m^2 = Square metres.

TABLE 3. CANADA, SHIPMENTS OF REFRACTORIES, 1981-84

	1981		1982		1983		1984	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Monolithics	25 103	14,026	28 948	18,404	26 624	17,726	39 804	28,851
Fire brick and shapes	122 413	66,034	87 066	52,781	80 831	46,960	102 180	67,058
Cement and mortars	56 558	18,026	46 004	15,198	57 382	23,953	54 307	27,608
All other products[1]	...	34,002	...	26,753	...	30,918	...	28,331
Total	...	132,088	...	113,136	...	119,557	...	151,848

Source: Statistics Canada.
[1] Includes also castables.
... Figures not appropriate or not applicable.

TABLE 4. CANADA, CLAYS, CLAY PRODUCTS, CERAMIC PRODUCTS AND REFRACTORIES, PRODUCTION AND TRADE, 1970, 1975, 1980-85

	Production					
Year	Domestic Clays	Imported Clays[2]	Total	Refractory Shipments[1]	Imports	Exports
			($ million)			
1970	51.8	33.6	85.4	42.3	81.2	15.6
1975	78.4	59.1	137.5	65.0	177.4	25.1
1980	108.5	83.4	191.9	135.7	386.2	63.8
1981	119.1	85.1	204.2	132.1	432.0	65.7
1982	96.0	63.4	159.4	113.1	349.8	50.5
1983	129.1	57.8	186.9	119.6	374.2	56.0
1984	136.8	60.4	197.2	151.8	460.6	70.8
1985P	138.2	..	..	..	505.2	78.3

Source: Statistics Canada.
[1] Includes fire brick and shapes, refractory cements, mortars, and monolithics, plus all other products shipped. [2] Includes electrical porcelains, glazed floor and wall tile, sanitaryware, pottery, art and decorative ware plus all other products.
P Preliminary; .. Not available.

TABLE 5. CANADA, REPORTED CONSUMPTION[1] OF CLAYS, BY INDUSTRIES, 1982-85

	1982	1983	1984[2]	1985[P]
		(tonnes)		
China Clay				
Pulp and paper products[3]	92 997	97 255[r]	147 234	165 032
Ceramic products	6 680	10 267	9 527	9 468
Rubber and linoleum	5 951	6 568	7 225	7 850
Paint and varnish	5 510	6 189[r]	6 065	6 347
Other products[4]	74 513	21 049[r]	21 138	21 141
Total	185 651[r]	141 328	191 189	209 838
Ball Clay				
Ceramic products misc.	11 084	19 749	16 506	18 622
Refractories	11 969	2 578	2 280	2 271
Other[5]	78 951	45 049	51 084	45 418
Total	102 004	67 376	69 870	66 311
Fire Clay				
Refractory brick, mixes	14 546	7 311[r]	8 136	10 680
Foundries	8 936	7 346[r]	8 514	8 272
Other[6]	4 183	21 596[r]	27 383	17 906
Total	27 665	36 234[r]	44 033	36 858

[1] Reported from EMR survey on the consumption of nonmetallic minerals by Canadian manufacture plants. [2] Increase in number of paper and paper products and paper pulp companies surveyed. [3] Includes paper and paper products and paper pulp. [4] Includes refractory brick and mixes, fertilizer stock and poultry feed, glass fibre, chemicals, roofing, wire and cable and other miscellaneous products. [5] Includes structural clay products, cements, paper and paper products, paint and varnish and other miscellaneous products. [6] Includes structural clay products, ceramic products, paint and varnish, petroleum refining, and rubber products.
[P] Preliminary; [r] Revised.

TABLE 6. KAOLIN: WORLD PRODUCTION, 1982-85, MAJOR COUNTRIES

	1982	1983	1984[r]	1985[e]
		(000 tonnes)		
United States	5 770	6 530	7 210	7 070
United Kingdom	3 560	2 720	2 970	3 000
U.S.S.R.[e]	2 630	2 630	2 810	2 900
Colombia[1]	810	760	940	900
Spain[3]	700	680	840	850
South Korea	630	680	720	660
Czechoslovakia	530	660	670	650
India[1]	630[r]	650[r]	680	630
Brazil[2]	490	420	490	550
West Germany	450	410	410	420
Romania	410	410	410	410
France	350	340	310	310
Others	1 650	2 750	2 620	2 840
Total	19 140	19 640	21 180	21 190

Source: U.S. Bureau of Mines, 1985, clays, S. Ampian.
[1] Crude, saleable kaolin. [2] Processed.
[3] Included crude and washed kaolin.
[r] Revised; [e] Estimated.

TABLE 7. MAJOR CANADIAN MANUFACTURERS OF STRUCTURAL CLAY PRODUCTS AND REFRACTORIES, 1986, BY PROVINCE

Company	Plant Location	Products	Raw Material	Size[1] and Remarks
NEWFOUNDLAND				
Trinity Brick Products Limited	St. John's	building bricks	shale	(B)
NEW BRUNSWICK				
L.E. Shaw Limited	Chipman	facing brick, tiles, drainage and partition	shale	(E)
NOVA SCOTIA				
L.E. Shaw Limited	Lantz	brick, block and tile	common clay, ball clay	(E)
QUEBEC				
Bricade Estrielle Inc.	Westbury	facing brick	common clay	(A)
Canada Brick Co. div. of Laprairie	Laprairie	building brick and facing	shale	- (G) bought from Domtar Inc. in 1985
Citadel Brick Ltd. div. of Brampton Brick Limited	Beauport	building brick, drain tile and flue lining	shale	- (C) sold to Brampton Brick in 1986
Didier Refractories Corporation	Bécancour	refractory brick and shape, monolithics and mortar	alumina-silica, silica and basic	(E)
Dresser Canada, Inc. Canadian refractories div.	Grenville	refractory brick and shape, monolithics	alumina-silica and basic	(F)
Duquesne Refractories Limited	Dorval	refractory monolithics and mortar	alumina-silica and carbon	(A)
Montreal Terra-Cotta Inc.	Deschaillons	building brick, tile and flue lining	shale, common clay	(B)
Quigley Canada Inc.	Lachine.	refractory brick and shape, cements	fire clay, basic	(A)
St. Lawrence Brick Co. Limited	Laprairie	building brick	shale	(C)

TABLE 7. (cont'd)

Company	Plant Location	Products	Raw Material	Size[1] and Remarks
ONTARIO				
Amos C. Martin Limited	Parkhill Wallenstein	drain tile	shale	(A)
A.P. Green Refractories (Canada) Ltd.				
Acton div.	Acton	refractory brick and shape monolithics, insulation	alumina-silica	(A)
Weston div.	Weston		alumina-silica	(C)
Babcock & Wilcox Industries Ltd.	Burlington	refractory brick and shape monolithics, mineral wool	alumina-silica kaolin	(C)
Bimac Canada Metallurgical Limited	Burlington	refractory brick and shape, mineral wool	alumina-silica	(B)
BMI Refractories Inc.	Smithville	refractory brick and shape, mortar	alumina-silica and basic	(A)
Brampton Brick Limited				
Brampton div.	Brampton	building brick	shale	(C)
Toronto div.	Toronto	building brick	shale	- (D) bought from United Ceramics Limited in 1985
Canada Brick Co.				(E)
Burlington div.	Burlington	building brick	shale	- new plant in construction
Burlington div.	Burlington	building brick	shale	
F.B. McFarren div.	Streetsville	building brick	shale	
Mississauga div.	Mississauga	building brick	shale	- bought from Domtar Inc. in 1985
Ottawa div.	Ottawa	building brick	shale	-
Streetsville div.	Streetsville	building brick	shale	
Dochart Clay Products Co. Ltd.	Arnprior	tile	common clay	(B)
Dresden Tile Yard (1981) Limited	Dresden	building brick, tile and flue lining	shale	(A)
General Refractories Co. of Canada Ltd.	Smithville	refractory brick and shape, mortar	basic	(D)
George Coultis & Son Limited	Thedford	tile, drain tile	shale	(B)

TABLE 7. (cont'd)

Company	Plant Location	Products	Raw Material	Size[1] and Remarks
ONTARIO (cont'd)				
Glasrock Products of Canada Ltd.	Hamilton	refractory brick and shape, monolithics	alumina-silica and fire-clay	(A)
Halton Ceramics Limited	Burlington	block and tile	common clay and shale	(A)
Hamilton Brick Limited	Hamilton	building brick	shale	(B)
National Refractories and Minerals Corp.	Oakville	refractory monolithics, mortar and insulation	alumina-silica and basic	(C)
National Sewer Pipe Limited	Oakville	flue lining and sewer pipe	shale and fire clay	(B)
North American Refractories a division of General Chemical Canada Ltd.	Caledonia	refractory monolithics, mortar and insulation	alumina-silica	(B)
Plibrico (Canada) Limited	Burlington	refractory monolithics, mortar and mineral wool	alumina-silica zircon and basic	(E)
R & I - Ramtite Canada Limited C-E Refractories div.	Welland	refractory monolithics and mortar; brick	alumina-silica	(C)
Riverside Refractories Canada Limited	Nanticoke	refractory shapes and mortars	alumina-silica	(A) - in construction in 1986; completion in 1987
MANITOBA				
I.XL Industries Ltd. Red River Brick and Tile div.	Lockport	brick and tile	common clay	(E)
SASKATCHEWAN				
A.P. Green Refractories (Canada) Ltd.	Claybank	brick and shape	alumina-silica	(A)
I.XL Industries Ltd. Western Clay Products div.	Regina	facing brick, flue lining and sewer-pipe	stoneware clay	(A)
Thunderbrick Limited Estevan Brick div.	Estevan	building brick	ball clay	(C)

TABLE 7. (cont'd)

Company	Plant Location	Products	Raw Material	Size[1] and Remarks
ALBERTA				
I.XL Industries Ltd.				
Medicine Hat Brick and Tile div.	Medicine Hat	brick, block, tile	common clay	(D)
Medicine Hat Sewer Pipe div.	Medicine Hat	sewer pipe and flue lining	common clay	(A)
Northwest Brick and Tile div.	Edmonton	building brick	common clay	(B)
Redcliff Pressed Brick div.	Redcliff	facing brick and fire brick	common clay	(B)
BRITISH COLUMBIA				
Clayburn Refractories Ltd.	Abbotsford	refractory brick, mortar and monolithics	alumina-silica	(D)
Fairey & Company, Limited	Surrey	refractory brick and shape, monolithics, mortar	alumina-silica	(A)
Sumas Clay Products Ltd.	Sumas	brick, drain tile and flue lining	common clay	(C)

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[1] Size keys: (A) up to 25 employees; (B) 25-49; (C) 50-99; (D) 100-199; (E) 200-499; (F) 500-999; (G) over 1000 employees.

Coal and Coke

J.A. AYLSWORTH

For the first time in many years Canada's coal industry will not set records for the production or export of coal in 1986. Statistics for the year indicate that the volume of Canadian production will be down 6 per cent over 1985 to 57.0 million tonnes (t) while exports decreased by 5 per cent to 25.9 million t. For the second consecutive year imports and domestic consumption will also decrease, the former by 12 per cent to 13.1 million t and the latter by 8 per cent to 44.6 million t.

The value of production also declined in 1986, for the first time in several years, reflecting both a decreased level of output and a lower average price received for bituminous coal. The total value of Canadian output, f.o.b. the mine, was $1,610 million, down $296 million or 16 per cent from 1985. British Columbia registered the largest absolute decrease of $225 million, reflecting both an 11 per cent reduction in the volume of its bituminous coal production and a 10 per cent decrease in the average per tonne value for this coal. The majority of British Columbia's output is exported to metallurgical and thermal coal markets in Asia, and the volume and price reductions reflect the surplus of coal available in this and other markets. In absolute terms Alberta recorded the second largest reduction of $69 million, reflecting an 11 per cent reduction in both the volume and price of its bituminous output. Approximately 65 per cent of Alberta's bituminous production is exported.

The value of coal output declined in Nova Scotia, New Brunswick, and Saskatchewan in 1986. Unlike the case of bituminous production in British Columbia and Alberta, these declines only reflected reductions in output. The average value per tonne of coal produced increased in each province. The only instance in which both the volume and value of coal output increased was sub-bituminous production in Alberta. In this case, the volume grew by 8 per cent and the value of output rose by 12 per cent, the latter figure reflecting an increase in the average per tonne value as well as the growth in output.

In spite of these fluctuations, there were signs that the industry looks forward to the future with guarded optimism. Two new mines, one in eastern and one in western Canada, are under development. Trial anthracite cargoes have been shipped from western Canada to markets in Asia, Europe and eastern Canada. Other potential mines are under investigation. Three coal-fired power stations are either under construction or in the planning stage and others are proposed for the 1990s.

Government funded and private sector coal research, development and demonstration work (R, D & D) continued to concentrate on improving coal recovery, and the environmentally sound combustion of coal. Late in the year, the commissioning of a federally-financed circulating fluidized bed (CFB) boiler began in Chatham, New Brunswick. The project is part of a program to demonstrate that simultaneous combustion of high sulphur coal in combination with oil shale can be achieved in a CFB boiler in an economical and environmentally acceptable manner. The combustion of coal water fuels in an oil-designed boiler was also initiated in 1986 with test results to be available in 1987.

The Canadian coal industry responded to the challenges of an evolving and restructuring world coal market by, among other things, selling into new markets such as the steel industry in Chicago, central and eastern Canada, and the power utility market in Florida. Canadian coking coal was also marketed to Portugal for the first time in 1986.

However, signals in the international market especially late in the year, suggest that 1987 will be another difficult year with a continuing oversupply of coal and resulting downward pressures on both prices and volumes. These pressures in the last few years have led to major thrusts within the Canadian industry to reduce costs and improve productivity and to some corporate restructuring in both the domestic and export sectors.

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REPORT ON THE EXPANDED USE OF WESTERN CANADIAN COAL IN ONTARIO

In August 1986 the report: "Western Canadian Low-Sulphur Coal - Its Expanded Use in Ontario" was released. The report, prepared by a federal-provincial Task Force, and jointly issued by the federal Ministers of Environment, Mines and Transport and the Ontario, Saskatchewan, Alberta and British Columbia Ministers of Environment followed a 1984 Ontario-Alberta report which assessed the costs and benefits of increasing western coal consumption in Ontario. The 1986 report focused on the role western coal could play in reducing acid gas emissions from Ontario Hydro's coal burning power plants.

Ontario Hydro is required by provincial legislation to reduce its annual emissions of sulphur dioxide - a principal source of acid rain - by more than 50 per cent by 1994. The utility currently burns a mix of medium-sulphur coals from Pennsylvania and West Virginia and low-sulphur coals from British Columbia, Alberta and Saskatchewan.

The Task Force concluded that, while not the most cost effective option for Ontario Hydro, the increased use of low-sulphur western Canadian coal to reduce acid gas emissions has the potential to create up to 205,000 person years of employment over the next 15 years and to generate $4.1 billion in income. The report recommends that governments and the private sector actively pursue the increased use of western Canadian coal by exploring ways of lowering the mining and transportation costs of bringing western Canadian coal to Ontario and by initiating funding for the development and demonstration of new, more effective technologies for upgrading western Canadian coal.

PRODUCTION AND MINE DEVELOPMENTS

Total coal production in eastern Canada in 1985 remained virtually unchanged from the previous year at 3.2 million t with Nova Scotia production approaching 2.7 million t and New Brunswick production 490 000 t. The mines operated by Cape Breton Development Corporation (CBDC) near Sydney produced nearly 2.5 million t of coal primarily for markets in Nova Scotia, but also for markets in other parts of Canada, and for export to European, Latin American and Asian customers. During 1986, CBDC delivered 1.9 million t of coal to Nova Scotia Power Corporation's (NSPC) four electrical generating stations, about 485 000 t of coking and thermal coal to overseas customers, and approximately 60 000 t to industrial consumers in Quebec.

Production will increase in 1987 with the official opening of the Phalen mine. This operation, which will eventually employ over 700 miners and produce 1.5 million tpy, is scheduled to achieve full production levels by the end of 1987. One-half of its output will be available for provincial electricity generation with the remainder targetted for export and other domestic markets. A number of small mines also produce coal for the local industrial and residential markets.

During 1986, Suncor Inc. completed work on the feasibility study of its Pictou County coal project and submitted its Stage II environmental impact assessment to provincial authorities. Development of the 600 000 to 900 000 tpy mine is dependent upon further business and market developments.

Coal production in New Brunswick is controlled by N.B. Coal Limited which is 90 per cent owned by the New Brunswick Electric Power Commission (NBEPC). Production in 1986, all of which was destined for NBEPC generating stations, fell 13 per cent to 490 000 t due to reduced demand for coal and mechanical problems at the mine. N.B. Coal Limited is considering expanding coal output and purchasing a sixth dragline to expand future market opportunities.

Coal production in Saskatchewan fell by 14 per cent in 1986 to 8.3 million t. This was due to decreased provincial utility demand which normally takes up between 80 per cent and 90 per cent of yearly provincial production. Other markets for Saskatchewan lignite coal include utility and industrial consumers in Manitoba and Ontario. Coal requirements in some of these markets declined as a result of the impact of the lower oil prices and increased interfuel competition.

Alberta was the only province to register an increase in coal production in 1986 with total output increasing by 507 000 t or 2 per cent to 25.2 million t. This increase consisted of an 8 per cent increase in sub-bituminous production, to 18.2 million t, and an 11 per cent decrease in bituminous production, to 7.0 million t. All of Alberta's sub-bituminous coal is used within the province for the generation of electricity. Bituminous coal is sold domestically to utilities in Alberta and Ontario and internationally to steel companies, utilities and industrial users in Asian, European, Latin American, and United States markets.

One new mine is under active development in Alberta and a second is under consideration. The Genesee mine which will initially supply 2 million t of sub-bituminous coal to the new Genesee Generating Station near Edmonton, is a joint venture between Fording Coal Limited and Edmonton Power. The smaller Brooks mine in southern Alberta is under study by Fording Coal Limited.

British Columbia's coal production fell by 11 per cent or 2.6 million t in 1986 to 20.4 million t reflecting both difficult world market conditions and unusually lengthy labour disputes at the province's largest coal producer, Westar Mining Ltd. Nearly all of British Columbia's output is exported to overseas markets, although a modest amount is also marketed domestically to Ontario Hydro.

In spite of this decrease in output, several properties are under active consideration in British Columbia for development later in this decade or early in the 1990s. The most advanced of these properties is the Mount Klappan anthracite coal project of Gulf Canada Corporation. Feasibility studies on the major elements of this mine have been completed and test shipments of anthracite products have been sent to European, Quebec and South Korean destinations. The Stage II application and request for approval in principle are scheduled to be submitted to the provincial government in early-1987. Current plans call for the mine to have an initial annual design capacity of 1.5 million t. The coal would be trucked approximately 250 km to the ice-free port of Stewart for export. If formal contracts are signed during 1987 development of the mine could occur before the end of the 1980s.

Two other mines are in the evaluation phase in British Columbia. One is the Telkwa coal project of Crows Nest Resources Limited in north-central British Columbia and the other is the Quinsam coal project on Vancouver Island, a jointly owned project between Brinco Coal Corporation and Weldwood of Canada Limited.

DOMESTIC COAL UTILIZATION

Preliminary figures suggest that domestic coal consumption in 1986 will total 44.6 million t, down 8 per cent over 1985. Virtually all of this decrease is accounted for by reductions in coal demand from provincial utilities.

Coal demand in the other major coal consuming sectors, the steel industry and the general industrial category, remained relatively unchanged from 1985. The steel industry consumed 6.1 million t in 1986, down about 2 per cent from the previous year, while "other" consumption, primarily general industrial and commercial uses, totalled 2 million t, equal to 1985 consumption levels.

Coal consumption in Nova Scotia in 1986 was 2.3 million t, up 2 per cent over 1985. This increase is primarily due to the use of 164 000 t of coal by Sydney Steel Corporation (SYSCO). The coke ovens were on-stream all year in 1986 following a shutdown for most of 1985. About 75 per cent of the coal used by SYSCO came from local sources with the remainder coming from western Canada.

In addition to small volumes of coal used in the "other" sector, the majority of Nova Scotia coal consumption occurs in the four generating stations of Nova Scotia Power Corporation (NSPC). Consumption at these stations in 1986 totalled 2.1 million t, down slightly from 1985 levels. Coal supplied approximately 72 per cent of the electricity generated by NSPC in 1986 and will provide a larger percentage in the future as new coal fired power facilities come on-stream in 1987 and early in the next decade.

The conversion of a 150 megawatt unit at Point Tupper from oil to coal burning capacity is under way and is scheduled for completion in late-1987. When operating at full capacity this unit will annually consume 400 000 t of coal. Following this, the next major addition of coal-fired thermal generating capacity to the NSPC system will not occur until the early-1990s when a new 150 megawatt unit will be brought into service at a location yet to be announced.

Coal consumption in New Brunswick declined by 12 per cent in 1986, to 469 000 t due primarily to a reduction in the use of coal to produce electricity. A decision on the possible conversion of the three unit, 1005 megawatt Coleson Cove generating station from oil to coal remained under consideration in 1986. If conversion of this plant were to be undertaken it would proceed one unit at a time.

Quebec coal demand is confined to industrial comsumers within the "other" category and totalled 642 000 t in 1986, up about 1 per cent over 1985.

For the second consecutive year, total coal consumption and consumption of coal for the generation of electricity both declined in Ontario. Statistics for the year indicate that total consumption fell by 12 per cent in 1986 to 15.9 million t, while coal use by Ontario Hydro was 9.2 million t, down 17 per cent compared with 10.985 million t in 1985. The decline in coal demand in 1986 is due to the greater availability and utilization of nuclear generating capacity and to an overall reduction in electricity exports generated from coal.

Of the total coal consumed by Ontario Hydro, about 70 per cent was bituminous coal from the United States, about 20 per cent bituminous coal from Alberta and British Columbia mines, and about 10 per cent lignitic coals from Saskatchewan. Forecasts suggest that coal consumption will continue to decline in 1987 and for the next few years as new nuclear units come on-stream, but could begin to grow again in the mid-1990s.

Coal consumption by the steel industry in Ontario totalled 5.9 million t in 1986, down 5 per cent from 1985, while other coal use (industrial and commercial) declined by 9 per cent to 830 000 t.

Coal utilization in Manitoba totalled 297 000 t in 1986, down just 31 per cent from 1985. Coal-fired plants produced about 1 per cent of the electricity generated in the province. Other coal demand in Manitoba increased to 186 000 t in 1986.

Total coal consumption in Saskatchewan decreased by 18 per cent to 7.0 million t in 1986. A general reduction in provincial load requirements and the use of new hydro capacity were responsible for this decrease. Power generation accounts for 98 per cent of the total coal demand in Saskatchewan and in 1986 totalled 6.8 million t, down from 8.3 million t in 1985. Longer term increases in coal demand were, however, assured by the decision by the provincial utility to build a new 300 megawatt coal fired power station in the southeastern corner of the province by 1991. Construction of this station, which will be fueled from nearby lignite deposits, will begin in 1987.

Alberta remained Canada's leading coal consuming province in 1986, although it, like all the other provinces, experienced a reduction in total demand. Consumption of coal for the generation of electricity totalled 17.7 million t, down 2 per cent from the record level of 18.1 million t in 1985. This decrease occurred in spite of the commercialization of a 380 megawatt unit at the Sheerness Generating Station owned jointly by Alberta Power Limited and TransAlta Utilities Corporation. This new unit consumed approximately 1 million t of coal during the year.

The next major coal-fired station addition in the province will be the first of two 400 megawatt units at Edmonton Power's Genesee generating station southwest of Edmonton. Construction of this unit resumed in 1986 after two deferrals and is now scheduled to come on-stream in 1989. Other new coal-fired units are planned for the 1990s.

Coal consumption in British Columbia is limited to the industrial sector and totalled 71 000 t in 1985. Consumption in 1986, however, more than doubled to 152 000 t as the result of the use of a coal-water fuel in a cement kiln in a plant near Vancouver. Over 90 per cent of the natural gas previously used in the plant has been replaced with a coal-water fuel in an experiment carried out by the cement company with the support of the federal government.

TRENDS, DEVELOPMENTS, AND OUTLOOK

The world recession of the early-1980s, combined with economic and institutional changes under way in many mineral and energy producing and consuming nations, has already had, and will continue to have, significant impacts on the rates of growth of world and domestic coal markets. It is within this global context that the Canadian industry must adjust and prepare for the future.

On the surface, the Canadian industry appears to have fared well in the 1980s. While world coal trade grew by 43 per cent between 1979 and 1985, Canadian coal exports increased by an impressive 100 per cent. Only Australia, among the other major coal traders, with an increase of 119 per cent, exceeded the Canadian export growth level. During the same period, South African exports grew by 89 per cent and United States exports by 41 per cent.

Impressive as these growth figures may appear, however, they mask an international industry caught up in major structural, technological and institutional changes.

The world shortage of coal in the late-1970s and very early-1980s has been replaced with oversupply, falling prices and expanding capacity. The global recession of the early-1980s accentuated the structural and other changes already under way in the established steel industries around the world. The impacts on the Japanese steel industry, which in 1985 purchased 62 per cent of Canada's coking coal exports, were especially important because of its pre-eminent position in world coking coal markets.

Technological changes, including improvements in existing blast furnace efficiencies and the trend towards electric arc furnaces contributed to reductions in overall demands for coal in several steel producing countries.

Specific developments, including a growth in steel production and export potential in developing countries such as South Korea, Taiwan and Brazil, compounded problems for traditional steel producers in Japan, Europe and the United States. More recently, currency exchange rate fluctuations further eroded markets of established steel producers, especially that of Japan due to the appreciation of the yen.

The resulting slowdown in the growth of steel production in addition to a slackening in the pace of growth in energy demand, plus major expansions in new coal export capacity produced an unprecedented excess capacity in world coal markets in the early-1980s.

The Canadian coal industry adjusted to these evolving market forces by diversifying not only with respect to the countries and end users receiving its coal, but also with respect to the products it sold. Recent increases in sales to existing and new markets in Asia, Europe and even the United States attest to progress in this area. Increased sales of the so-called "weak" or "soft" coking coals can be viewed as a success in adapting to new market opportunities, although they add little to already seriously depressed profit margins.

On the domestic scene, growth in demand for Canadian coal is more predictable but not necessarily without slowdowns and delays. Energy demand growth rates vary among provinces, and while the general trend is upwards, this does not necessarily translate into increased utilization of coal as most provinces have a variety of generation options. Nevertheless, coal demand is forecast to grow in several provinces over the next few years.

The prospects for the Canadian coal industry will vary depending on the market in which the coal is sold. On the international scene, particular factors such as the sanctions issue related to South African coal, the changes under way in world steel industries, exchange rate relationships and the development of major new production capabilities in such countries as Colombia, China and elsewhere will do much to influence the size and shape of Canadian exports in the years ahead.

Other factors will also play an important role in shaping the future of Canada's coal industry. The rate and success of coal R, D & D on new, more efficient and more environmentally benign utilization technologies will impact on both domestic and international markets. Restructuring and perhaps consolidation in both the domestic and export sectors of the Canadian industry, in combination with continuing efforts to increase productivity and contain costs, will go hand in hand with increased market and product diversification. Given current and forecasted levels of international and domestic demand, it is widely believed that the era of major annual increases in Canadian production and exports is over. Barring unforeseen political or demand-supply interruptions in world trade patterns, the near-term future for international coal trade appears to be one of slow growth, continued downward pressure on prices and slowly changing trade patterns. These pressures and trends can be expected to create significant changes in both Canada's and other countries' coal industries in the 1990s.

TABLE 1. SUMMARY OF COAL SUPPLY BY TYPE AND VALUES, 1982-86

	1982		1983		1984		1985		1986	
	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)
DOMESTIC[1]										
Bituminous										
Nova Scotia	3 052	175,000	2 986	144,000	3 094	162,000	2 800	158,000	2 695	155,000
New Brunswick	499	24,000	558	29,000	564	30,000	560	30,000	490	27,000
Alberta	6 978	338,000	7 315	371,000	7 630	337,000	7 841	331,000	6 994	262,000
British Columbia	11 768	654,000	11 697	588,000	20 775	1,020,000	22 994	1,106,000	20 359	881,000
Total	22 396	1,191,000	22 556	1,132,000	32 062	1,549,000	34 195	1,625,000	30 538	1,325,000
Sub-bituminous										
Alberta	13 021	88,000	14 464	112,000	15 422	126,000	16 871	146,000	18 225	163,000
Lignite										
Saskatchewan	7 494	73,000	7 760	95,000	9 918	131,000	9 672	135,000	8 281	122,000
Total	42 811	1,352,000	44 780	1,339,000	57 402	1,806,000	60 738	1,906,000	57 044	1,610,000
IMPORTED[2]										
Bituminous and anthracite briquettes	15 773	1,132,000	14 667	1,031,000	18 352	1,366,000	14 867	1,124,000	13 125	999,000
Total	58 584	2,484,000	59 447	2,370,000	75 754	3,172,000	75 605	3,030,000	70 169	2,609,000

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] F.o.b. mines. [2] Value at United States ports of exit.

TABLE 2. PRODUCER'S DISPOSITION OF CANADIAN COAL[1], 1985

Destination	Nova Scotia	New Brunswick	Saskatchewan	Alberta	British Columbia	Canada
			(000 tonnes)			
Newfoundland	1	-	-	-	-	1
Prince Edward Island	7	-	-	-	-	7
Nova Scotia	2 217	-	-	31	-	2 248
New Brunswick	62	557	-	-	-	619
Quebec	61	-	-	-	-	61
Ontario	-	-	981	1 415	638	3 034
Manitoba	-	-	388	1	52	441
Saskatchewan	-	-	8 304	1	29	8 334
Alberta	-	-	-	18 010	-	18 010
British Columbia	-	-	-	-	170	170
Total Canada	2 348	557	9 673	19 458	889	32 925
Japan	-	-	-	4 123	14 418	18 541
Others	62	-	-	1 303	7 074	8 839
Total shipments	2 810	557	9 673	24 884	22 381	60 305

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Saleable coal (raw coal, clean coal and middling sales).

- Nil.

TABLE 3. SUMMARY OF COAL SUPPLY-DEMAND, 1975-86

Year	Canada Production				Imports				
	Bituminous	Sub-Bituminous	Lignite	Total	Anthracite	Bituminous	Total Available	Domestic Consumption	Exports
				(million tonnes)					
1975	15.8	6.0	3.5	25.3	0.4	15.4	41.1	25.5	11.4
1976	14.4	6.4	4.7	25.5	0.3	14.3	40.1	28.2	11.9
1977	15.3	7.9	5.5	28.7	0.4	15.0	44.1	30.8	12.4
1978	17.1	8.3	5.1	30.5	0.3	13.8	44.6	31.7	14.0
1979	18.4	9.6	5.0	33.0	0.2	17.3	50.5	34.8	13.7
1980	20.2	10.5	6.0	36.7	0.3	15.5	52.5	37.3	15.3
1981	21.7	11.6	6.8	40.1	0.4	14.4	54.9	38.4	15.7
1982	22.3	13.0	9.5	42.8	0.3	15.5	58.6	41.5	16.0
1983	22.5	14.5	7.8	44.8	0.3	14.4	59.5	43.6	17.0
1984	32.1	15.4	9.9	57.4	0.2	18.1	75.7	48.6	25.1
1985	34.2	16.8	9.7	60.7	0.3	14.6	75.6	48.7	27.4
1986	30.5	18.2	8.3	57.0	0.4	12.7	70.1	44.6	25.9

Sources: Statistics Canada; Energy, Mines and Resources Canada.

TABLE 4. COAL USED BY THERMAL POWER STATIONS IN CANADA, BY PROVINCES, 1967-86

	Nova Scotia	New Brunswick	Ontario	Manitoba	Saskatchewan	Alberta	Total Canada
				(000 tonnes)			
1967	758	275	4 435	38	1 334	1 427	8 267
1968	646	240	5 523	179	1 354	2 128	10 070
1969	676	150	6 424	51	1 123	2 378	10 802
1970	548	113	7 696	503	1 969	2 951	13 780
1971	689	271	8 560	446	1 996	3 653	15 615
1972	663	281	7 599	410	2 145	4 113	15 211
1973	585	193	6 615	386	2 806	4 474	15 059
1974	606	292	6 721	132	2 902	4 771	15 424
1975	571	248	6 834	323	3 251	5 345	16 572
1976	730	207	7 612	979	3 521	5 996	19 045
1977	572	198	8 795	1 113	4 304	7 461	22 443
1978	771	151	9 097	341	4 585	8 029	22 914
1979	644	198	9 901	73	4 956	9 181	24 956
1980	1 052	315	10 779	240	4 972	10 424	27 782
1981	1 126	515	11 460	332	4 935	11 445	29 813
1982	1 300	548	12 484	184	5 897	13 242	33 656
1983	1 400	564	13 025	109	6 625	14 492	36 216
1984	1 974	610	13 413	163	7 925	16 123	40 208
1985	2 235	521	10 985	253	8 290	18 112	40 396
1986	2 137	469	9 172	111	6 786	17 719	36 394

Sources: Statistics Canada; Energy, Mines and Resources Canada.

TABLE 5. EXPORTS OF CANADIAN COAL BY DESTINATION AND VALUE[1]

Country	Total	Value
	(kilotonnes)	($000)
	1985	
Japan	18 541	1,430,317
South Korea	3 580	223,696
Brazil	899	62,848
France	736	..
Hong Kong	506	..
Taiwan	496	..
United Kingdom	330	..
Denmark	328	..
West Germany	326	..
Sweden	313	..
United States	265	..
Mexico	195	..
Pakistan	178	..
Belgium	140	..
Chile	130	..
Spain	112	..
Italy	67	..
Philippines	57	..
Finland	56	..
India	38	..
Iran	31	..
Netherlands	28	..
Greece	26	..
Total	27 378	1,962,632
	1986	
Japan	17 549	1,225,736
South Korea	3 127	175,511
Brazil	1 130	75,178
France	928	..
Taiwan	549	..
United Kingdom	384	..
United States	343	..
Sweden	280	..
Denmark	278	..
Hong Kong	249	..
Pakistan	228	..
Netherlands	178	..
West Germany	178	..
Chile	177	..
Belgium	123	..
Portugal	70	..
Yugoslavia	61	..
Philippines	60	..
Mexico	51	..
Total	25 943	1,703,924

Source: Statistics Canada and Energy, Mines and Resources Canada joint survey, Coal.

[1] F.o.b. Port of Export.

.. Not available.

TABLE 6. CANADA, COAL PRODUCTION, IMPORTS, EXPORTS AND CONSUMPTION, 1981-86

	Production	Imports	Exports	Domestic Consumption
		(000 tonnes)		
1981	40 088	14 836	15 705	38 367
1982	42 811	15 773	16 004	41 478
1983	44 780	14 667	17 011	43 649
1984	57 402	18 352	25 138	48 699
1985	60 738	14 867	27 378	48 656
1986[1]	57 044	13 125	25 943	44 558

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Preliminary figures or estimates.

TABLE 7. SUMMARY OF COAL DEMAND, 1981-86

	1981	1982	1983	1984	1985	1986
			(000 tonnes)			
DEMAND						
Thermal Electric						
Canadian	20 998	24 033	26 748	29 935	32 563	30 035
Imported	8 815	9 623	9 468	10 273	7 833	6 359
Total	29 813	33 656	36 216	40 208	40 396	36 394
Metallurgical						
Canadian	784	229	102	-	52	243
Imported	5 593	5 347	5 481	6 542	6 210	5 891
Total	6 377	5 576	5 583	6 542	6 262	6 134
General Industry						
Canadian	1 133	1 260	847	813	582	655
Imported	1 044	986	1 003	1 136	1 416	1 375
Total	2 177	2 246	1 850	1 949	1 998	2 030
Exports						
Canadian	15 705	16 004	17 011	25 138	27 378	25 943
Total						
Canadian	38 620	41 526	44 708	55 886	60 575	56 876
Imported	15 452	15 956	15 952	17 951	15 459	13 625
Grand Total	54 072	57 482	60 660	73 837	76 034	70 501

Sources: Statistics Canada; Energy, Mines and Resources Canada.
- Nil.

TABLE 8. CANADA, COKE PRODUCTION AND TRADE, 1975-85

	Production		Imports		Exports	
	Coal	Petroleum	Coal	Petroleum	Coal	Petroleum
			(tonnes)			
1975	5 277 837	270 685	546 456	572 557	96 081	161 576
1976	5 289 185	678 432	287 249	591 859	169 895	136 970
1977	4 845 066	921 363	382 827	986 678	198 727	157 191
1978	4 967 664	1 014 076	553 349	973 985	217 995	134 762
1979	5 775 141	1 105 433	520 534	980 657	228 601	125 416
1980	5 249 744	1 156 444	626 923	908 322	319 554	150 200
1981	4 659 007	1 098 397	653 645	935 929	190 879	200 149
1982	3 999 117	1 083 129	453 915	650 810	129 793	104 897
1983	4 120 002	986 730	576 649	759 954	45 606	65 323
1984	4 900 478	1 072 983	660 257	886 734	116 226	55 300
1985	4 683 770	1 099 808	369 224	866 530	46 882	45 968

Cobalt

R.G. TELEWIAK

Western world consumption of cobalt from primary sources is estimated to have changed little from the 18 000 t recorded in 1985. An additional 2 000 t of cobalt contained in secondary material was also utilized. Supplies of primary cobalt were plentiful and an estimated 3 000 t of inventories were accumulated.

Demand from the superalloy sector, which accounts for about one third of the total, was again strong. This was led by the manufacture of new commercial and military jet engines, as well as normal replacement of jet engine parts, primarily turbine blades.

CANADIAN DEVELOPMENTS

The two mine producers of cobalt, Inco Limited and Falconbridge Limited, recover cobalt as a by-product of nickel-copper production. Inco operates mines in Sudbury, Ontario and Thompson, Manitoba. Falconbridge's mines are also in Sudbury.

At Sudbury, Inco continued with its aggressive program to reduce costs, which were lower in 1986 than in 1980. Cost reductions have been achieved in all parts of the operation, but particularly in mining. One of the key factors in mining has been the gradual switch to bulk mining methods. In 1986, 83 per cent of Sudbury production came from bulk mining methods, compared to 32 per cent in 1982.

In Manitoba, Inco officially opened its Thompson open-pit mine on September 23. This high grade mine, which cost $100 million to develop, averages 2.7 per cent nickel and has simpler metallurgy and better recoveries than the Pipe mine which it replaces. Consequently, it is one of the world's lowest cost mines.

Falconbridge continued its three-year, $216 million program of preproduction, development and capital expenditures which was started at Sudbury in 1985. Major parts of the program include deepening the Strathcona No. 1 shaft and development of the Craig and Onaping deposits. Falconbridge had fallen behind in mine development a few years ago, due to other priorities.

At Port Colborne, Ontario, Inco operated its cobalt refinery at its capacity of 900 tpy of electrolytic cobalt rounds. The refinery was opened in 1983 and high quality cobalt metal is produced for use primarily in the superalloy sector.

Cobalt feedstock supply for Sherritt Gordon Mines Limited's refinery at Fort Saskatchewan, Alberta, remained about the same as in 1985. Sherritt Gordon toll-refines cobalt for several producers and also custom refines cobalt. With the termination of the AMAX Inc. contract in late 1985, there was a decrease in the amount of material toll-refined.

Geddes Resources Limited continued to hold the Windy Craggy copper-cobalt-gold deposit in northwestern British Columbia but no detailed exploration was undertaken. The company is planning to start a 1 700 m adit into the deposit in 1987, providing sufficient financing can be obtained. The adit will be driven through the zone rich in cobalt and into the part of the deposit with higher gold values. The deposit is reported to contain 318 million t of mineralization grading 1.5 per cent copper, 0.08 per cent cobalt plus gold values.

WORLD DEVELOPMENTS

Producers operated, on average at a little over 60 per cent of capacity. Zaire, which is the largest producer, operated at about 50 per cent of capacity and produced an estimated 11 000 t of cobalt. Zambia, the second largest producer in the western world, operated at close to its annual capacity of 5 100 t.

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In Finland, Outokumpu Oy announced that it would suspend production for four months in early 1987 at its Kokkola refinery, due to weak international cobalt market conditions. The company stated that if market conditions did not improve, the shutdown would be extended.

Nonoc Mining and Industrial Corporation in the Philippines operated intermittently throughout the year. Initially, production was reduced due to a labour dispute and then halted at year-end due to weak market conditions. An early resumption of production is not expected.

Nonoc had been shipping its nickel-cobalt mixed sulphide to Sumitomo Metal Mining Co. Ltd. in Japan for refining. The other Japanese cobalt producer, Nippon Mining Company Ltd., suspended cobalt refining due to a lack of feedstock. Nippon had been obtaining its feedstock from Queensland Nickel Pty. Ltd.'s Greenvale mine in Australia, but its contract for this material expired at the end of April.

PRICES

Cobalt prices were $US 11.70 at the start of 1986. Zaire and Zambia had instituted a producers price of $11.70 in April 1983 and prices had held close to that level until early 1986.

Zambia was reported to have tried in early-1986 to gain market share by discounting. Zaire and other producers matched the discounts and prices fell dramatically. By September, prices had fallen to about $3.80 per pound.

By late November, Zambia and Zaire had moved to stabilise the market by establishing a producer price of $US 7.00 per pound.

USES

One of the major uses for cobalt is in superalloys where it improves the strength, wear and corrosion resistance characteristics of the alloys at elevated temperatures. The major use of cobalt-base superalloys is in turbine blades for aircraft jet engines and gas turbines for gas pipelines. Cobalt-based superalloys normally contain 45 per cent or more cobalt, while nickel and iron based superalloys contain 8 to 20 per cent cobalt.

Although the demand for cobalt in the production of magnets has been declining in recent years, this is still an important use for cobalt. Consumption of cobalt in this sector is almost one half what it was in 1970.

Cobalt-based alloys are used in applications where difficult cutting is involved and high abrasion resistance qualities are required. The most important group of cobalt-base alloys is the stellite group, containing cobalt, tungsten, chromium and molybdenum as principal constituents. Hard-facing or coating of tools with cobalt alloys provides greater resistance to abrasion, heat, impact and corrosion.

Cobalt metal powder is used as a binder in making cemented tungsten carbides for heavy-duty and high-speed cutting tools.

As a chemical product, cobalt oxide is an important additive in paint, glass, and ceramics. Cobalt is also used to promote the adherence of enamel to steel for applications such as appliances, and steel to rubber for the construction of steel-belted tires. A cobalt-molybdenum-alumina compound is used as a catalyst in hydrogenation and in petroleum desulphurization.

OUTLOOK

Over the long term, cobalt consumption is expected to increase at an annual rate of 1 to 2 per cent. The price volatility in the late-1970s and early-1980s, along with some concern over potential security of supply, has resulted in considerable substitution away from cobalt in certain uses and is a major factor in the forecast of a relatively modest increase.

Major consuming countries have expended considerable resources to find substitutes for cobalt in key applications. These programs have reduced the amount of cobalt used or eliminated it completely in certain applications. As an example, Pratt & Whitney Group of the United States has developed a jet engine combustor which consists of a nickel alloy, to replace a cobalt alloy. A heat resistant ceramic coating reportedly makes the nickel alloy at least as durable as the cobalt one.

Zaire and Zambia are the two largest producers in the world, accounting for about two thirds of cobalt capacity. The strategies which these two producers pursue, along with other possible events in these countries, will have a major impact upon supply and consequently on prices.

TABLE 1. CANADA, PRODUCTION TRADE 1984-86 AND CONSUMPTION 1983-85

	1984		1985		1986P	
	(kilograms)	($)	(kilograms)	($)	(kilograms)	($)
Production[1] (all forms)						
Ontario	1 687 632	48,583,550	1 731 269	60,433,575	2 142 675	48,465,165
Manitoba	435 701	12,542,960	335 546	11,526,462	343 820	7,776,865
Total	2 123 333	61,126,510	2 066 815	71,960,037	2 486 495	56,242,030
Exports					(Jan.-Sept.)	
Cobalt metal						
United States	1 149 521	25,326,000	1 300 047	30,661,397	1 123 144	20,251,015
United Kingdom	179 480	3,549,000	113 000	630,280	104 144	581,687
South Africa	-	-	431	10,439	-	-
Belgium-Luxembourg	136 995	764,000	125 000	697,211	84 000	468,529
Australia	3 929	118,000	6 253	224,043	9 497	340,352
Other countries	17 135	574,000	6 698	572,222	125 825	3,791,345
Total	1 487 060	29,330,000	1 551 429	32,803,592	1 446 610	25,432,938
Cobalt oxides and hydroxides[2]						
United Kingdom	321 000	5,951,000	267 000	7,436,000	249 000	7,057,000
United States	17 000	72,000	-	-	-	-
Belgium-Luxembourg	36 000	573,000	-	-	-	-
Total	374 000	6,596,000	267 000	7,436,000	249 000	7,057,000
Consumption[3]	1983		1984		1985P	
Cobalt contained in:						
Cobalt metal	82 615		85 736		70 853	
Cobalt oxide	10 563		19 923		22 297	
Cobalt salts	7 313		7 313		8 017	
Total	112 972	..	112 972	..	101 167	..

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Production (cobalt content) from domestic ores. [2] Gross weight. [3] Available data reported by consumers.

P Preliminary; - Nil; .. Not available.

TABLE 2. CANADA, COBALT PRODUCTION, TRADE AND CONSUMPTION, 1970, 1975 AND 1980-85

		Exports		Imports		
	Production[1]	Cobalt metal	Cobalt oxides and hydroxides	Cobalt ores[2]	Cobalt oxides and hydroxides[3]	Consumption[4]
	(tonnes)					
1970	2 069	381	837	..	..	148
1975	1 354	431	561	..	..	123
1980	2 118	325	1 091	2	26	105
1981	2 080	677	601	24	20	101
1982	1 274	585	230	2	30	81
1983	1 410	885	192	45	30	101
1984	2 123	1 487	374	-	-	113
1985	2 067	1 551	267	-	-	101P

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Production from domestic ores and cobalt content, including cobalt content of Inco Limited and of Falconbridge Limited shipments to overseas refineries. [2] Cobalt content. [3] Gross weight. [4] Consumption of cobalt in metal, oxides and salts.

P Preliminary; .. Not available; - Nil.

TABLE 3. WORLD PRODUCTION OF COBALT

	1982	1983	1984P	1985[e]
	(tonnes)			
Zaire	11 302	11 301	17 959	19 955
Zambia	3 251	3 199	4 617	4 617
Canada	1 404	1 158	2 325	3 075
Australia	1 479	1 179	1 088	834
Finland	1 036	1 035	952	952
Cuba	1 497	1 621	1 397	1 424
U.S.S.R.	2 268	2 358	2 630	2 721
Other	2 282	1 437	1 566	2 582
Total	24 518	23 715	32 534	36 161

Source: United States Bureau of Mines.

P Preliminary; [e] Estimate.

Columbium (Niobium)

D.G. FONG

Western world production of columbium, at 21 000 t of contained columbium pentoxide (Cb_2O_5) in 1986, declined 2 per cent from the previous year. Mine production in Canada reached a record level during 1986. However, this increase was more than offset by the lower output in Brasil which accounts for more than 80 per cent of the world's supply.

The 1986 world demand, estimated at 17 000 t Cb_2O_5 equivalent, fell due to lower consumption in the United States, Japan and Europe. Demand in the United States was reported to have dropped by 15 per cent. In Japan, the steel industry was seriously affected by the rising value of the yen. In Europe, lower orders from the Soviet Union for pipes affected the overall columbium consumption level, despite a strong performance in the special steel sector and particularly in the stainless steel industry in West Germany.

The demand for columbium in 1987 is expected to remain at the current low level. The rapid growth rate during the last two decades reached a plateau as conventional applications for the metal entered a mature stage and the expectation of high growth in new applications did not materialize. Also, the technological advancement in steel making, a slow down in the automotive market and a decline in pipeline construction have had a negative impact on the columbium market.

CANADIAN DEVELOPMENTS

Columbium is produced in Canada at the Niobec mine which is located at St-Honoré, Quebec. Production in 1986 increased by 5 per cent to 3 346 t of contained Cb_2O_5. Ore reserves at the mine in 1986 were 11 098 639 t at a grade of 0.659 per cent Cb_2O_5, compared with 10 945 281 t and 0.663 per cent respectively in 1985.

Cambior inc., created by the Province of Quebec as part of the government's privatization program, acquired in 1986 the 50 per cent interest in the Niobec mine that was previously owned by Société québécoise d'exploration minière (SOQUEM). Teck Corporation retained its 50 per cent equity interest in the mining operation.

Niobec became the only major world supplier of pyrochlore concentrate, following a decision in 1981 by Brazilian producers to convert all their output into intermediate products. Shipments of Canadian pyrochlore concentrates, containing about 60 per cent Cb_2O_5 are destined primarily for the United States, western Europe and Japanese markets.

Highwood Resources Ltd. signed an agreement in September with Hecla Mining Company of the United States to jointly develop the Thor Lake deposit in the Northwest Territories. Under the agreement, Hecla can earn a 50 per cent interest in Thor Lake by completing a feasibility and marketing study, reimbursing $8 million for the 50 per cent share of exploration expenditures, and bringing the property into production.

Thor Lake is a multimetal deposit which contains beryllium, yttrium, columbium, tantalum, gallium, zirconium and rare earths. During the last two years, Highwood Resources has completed a number of preproduction developments which included camp construction, underground developments and pilot plant testing. The company planned to construct a five-mile road to provide year-round access to the property. Due to the priority given to develop beryllium, test work on the concentration of columbium and yttrium is not yet finalised.

WORLD DEVELOPMENTS

Companhia Brasileira de Metalurgia e Mineraçao S.A. (CBMM) in Brasil, the world's leading columbium producer, began to accumulate inventories of ferrocolumbium because of lower demand. However, the Araxa mine, located about 400 km north of Sao Paulo, continued to operate at 65 per cent capacity throughout 1986. CBMM has an annual production capacity of 22 000 t of ferrocolumbium.

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CBMM is 52.65 per cent owned by Metropolitana de Comercio e Participacoes and 47 per cent by Molycorp, Inc. of the United States, and operates entirely under Brazilian management. Besides producing the standard grade ferrocolumbium which represents over 90 per cent of its total output, CBMM also produces a wide range of high purity columbium products including high purity ferrocolumbium, nickel-columbium, columbium metal, and crystal and optical grade columbium oxides.

As a dominant producer which supplies about 70 per cent of the world's need, CBMM sets its production to meet anticipated market demand; the other producers typically operate at capacity. Because of a small domestic market, nearly all of its output is destined for export; its principal export markets include Europe (45 per cent), the United States (25 per cent), Japan (12 per cent), Canada (6 per cent) and the U.S.S.R. (6 per cent).

CBMM received approval from the Brazilian government for the construction of a 40 tpy columbium metal plant which is expected to come on stream in 1989. The approval of the $US 6.2 million project will enable the company to buy imported equipment and special furnaces. CBMM currently produces columbium metal in Sao Paulo under an agreement with the Ministry of Industry and Commerce.

Mineracao Catalao de Goias S.A., located in southeastern State of Goias, about 300 km south of Brasilia, is controlled by the Anglo American Corporation of South Africa Ltd. The mine has an output capacity of 2 800 tpy of ferrocolumbium, which is the sole product Catalao is marketing. Area II is mined by open-pit at a daily rate of 1 500 t of ore while Area I is in a stage of preproduction stripping. Ore reserves in Area II are 2 million t grading 1 per cent Cb_2O_5, whereas Area I has confirmed reserves of 10 million t with an average grade of 1.2 per cent Cb_2O_5.

USES

The steel industry is the largest consumer of columbium, which is used in the form of ferrocolumbium as an additive agent in high-strength low-alloy (HSLA) steels, stainless steels and heat-resisting steels. Although the quantity of contained columbium may be as low as 0.02 per cent, the yield strength and mechanical properties of the resulting steel are significantly improved. These characteristics are particularly important in applications such as large-diameter pipelines, automotive components, structural applications and drilling platforms.

High-purity columbium pentoxide is used mainly in superalloys for turbine and jet engines, which have traditionally been the second largest use after steels. A columbium addition to the cobalt and nickel based superalloys improves the high temperature characteristics of these alloys. In addition, columbium-based alloys containing tantalum, tungsten and zirconium are being used in the aeronautic and nuclear industries.

In the manufacture of high-alloy and stainless steels, columbium is used to impart resistance to corrosion at elevated temperatures, a property of particular importance in petroleum processing plants, heat exchangers for severe chemical environments and acid pressure vessels.

One of the important properties of pure columbium is its superior conductivity compared with other metals. Super conductivity is the loss of all resistance to direct electrical current at temperatures near absolute zero. This special property has allowed the construction of powerful electrical generators, which are much more efficient than conventional generators with copper wire windings. Also, because of the powerful magnetic field created by the superconductors, columbium is used extensively in the construction of nuclear magnetic imaging (NMI). In addition, many potential applications in electrical devices are being developed, including new types of motors, ship engines, electric generators and switch elements for computers.

Special high-purity columbium pentoxide is produced for optical applications. Additions of columbium pentoxide to optical glass give a high refractive index and thereby allow production of thin lenses for eyeglasses. This characteristic, along with others such as lightweight and durability, enable such lenses to be competitive with plastic lenses.

PRICES

Quoted prices for columbium remained unchanged during the year. Metals Week showed the Niobec concentrate price at

$US 5.73 per kg of contained Cb_2O_5. Prices quoted by CBMM were $US 12.35 per kg of contained Cb for standard grade ferrocolumbium, $US 39.02 per kg of contained Cb for vacuum grade ferrocolumbium, $US 37.48 per kg for nickel columbium and $US 65 per kg for columbium metal. Prices for the high purity oxides were quoted at $US 14 per kg for the catalytic grade and $US 45 to $60 per kg for the optical grade.

OUTLOOK

Growth expectations for columbium consumption have dropped from 8 per cent per year in the last two decades to less than 2 per cent in the 1980s. This shift was caused primarily by a lower requirement for columbium steel in the energy sector and an improvement in steelmaking technology. Also, despite the strong demand for columbium in superalloys during the last two years, the expectations for vigorous growth in high-purity columbium superconductors did not materialize and new applications such as catalysts and new carbides have not yet advanced beyond the research and development stage.

In regards to superconductors, construction of magnetic resonance imaging (MRI) has slowed considerably despite its being a much more powerful tool for medical diagnosis compared with X-ray machines. The main reason is largely the high capital cost of MRI. This situation is not expected to change significantly before the end of the decade. Also, the proposed construction of a $6 billion superconducting super collider in the United States is now considered unlikely, at least for the near future.

The outlook for the Canadian steel industry, a major user of columbium, is constrained by the projected soft demand for automobiles throughout 1987. Vehicle production is forecasted to decline by 7.5 per cent. Furthermore, oil and gas drilling is expected to continue to decline further, resulting in a drop in demand for both large and small pipes. The industry is forecasting a 10 per cent drop in pipe demand.

World consumption of columbium is forecasted to remain at the current low level in 1987, and to gradually return to the 20 000 t plateau by 1990. World mine production in 1987 is projected to be 16 900 t Cb_2O_5 equivalent, and to remain at this operating rate until inventories are reduced to normal requirements, which may not occur until about 1989. Annual mine production in Canada is forecasted at 3 000 t Cb_2O_5 equivalent during these years.

On the supply side, there will be excess production capacity well into the next decade. Brazil, with an abundance of proven and yet to be developed columbium reserves, will continue to be the dominant source for centuries to come while Canada, with large resources occurring in a number of undeveloped deposits across the country, will continue to be a strong alternative supplier to Brazil.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
CANADA					
32900-1	Columbium and tantalum ores and concentrates	free	free	free	free
35120-1	Columbium (niobium) and tantalum metal and alloys in powder, pellets, scrap, ingots, sheets, plates, strips, bars, rods, tubing or wire for use in Canadian manufactures (expires June 30, 1987)	free	free	25	free
37506-1	Ferrocolumbium, ferrotantalum, ferro-tantalum-columbium	free	4.2	5	free

MFN Reductions under GATT (effective January 1 of year given)	1986	1987
	(%)	
37506-1	4.2	4.0

UNITED STATES

601.21	Columbium ore	free

		1986	1987
		(%)	
628.15	Columbium metal, unwrought, other than alloys; and waste and scrap	3.9	3.7
628.17	Columbium, unwrought alloys	5.2	4.9
628.20	Columbium metal, wrought	5.9	5.5

Sources: The Customs Tariff, 1986, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated (1986), USITC Publication 1775; U.S. Federal Register, Vol. 44, No. 241.

PRICES

Prices as quoted in Metals Week in December 1985 and 1986, U.S. currency.

	1985	1986
	($)	
Columbium ore		
Columbite, per kg of pentoxide, cif U.S. ports[1]	7.70-11.02	4.41-5.51
Canadian pyrochlore, per kg, f.o.b. mine	5.73	5.73
Ferrocolumbium, per kg Cb, f.o.b. shipping point		
Low alloy	12.48	12.48
High purity alloy	39.02	37.48-38.58
Columbium metal, per kg 99.5-99.8%, fas shipping point		
Reactor ingot	72.75-88.18	66.14-72.75
Reactor powder	79.37-105.82	77.16-99.21

[1] The range reflects variations in the ratio of columbium pentoxide (Cb_2O_5) to tantalum pentoxide (Ta_2O_5).
cif - Cost, insurance and freight; f.o.b. - Free on board; fas - Free alongside ship.

TABLE 1. CANADA, COLUMBIUM (NIOBIUM) PRODUCTION, TRADE AND CONSUMPTION, 1970, 1975 AND 1979-86

	Production[1]	Imports Primary forms and fabricated metals		Exports[2]	Consumption
	Cb_2O_5 Content	Columbium	Columbium Alloys	Columbium Ores and Concentrates to United States	Ferrocolumbium and Ferro-tantalum-columbium (Cb and Ta-Cb Content)
			(kilograms)		
1970	2 129 271	..	..	576 227	132 449
1975	1 661 567	..	..	9 682	215 910
1979	2 512 667	855	W	509 953	360 152
1980	2 462 798	877	156	655 721	486 251
1981	2 740 736	913	303	419 865	455 500
1982	3 086 000	805	59	291 193	356 000
1983	1 744 722	967	396	543 599	359 000
1984	2 766 805	1 045	236	1 132 892	482 000
1985	2 928 700	821	499	1 279 764	447 000
1986P	2 950 000	673[3]	963[3]	1 240 415[3]	..

Sources: Energy, Mines and Resources Canada; Statistics Canada; U.S. Department of Commerce.
[1] Producers' shipments of columbium ores and concentrates and primary products, Cb_2O_5 content. [2] From U.S. Department of Commerce, Imports of Merchandise for Consumption, Report FT 135. Quantities in gross weight of material. [3] January to November 1986.
P Preliminary; .. Not available; W Withheld to avoid disclosing confidential company data.

Copper

W.J. McCUTCHEON

Canadian copper producers continued to experience financial difficulty in 1986 due to low metal prices. Some restructuring of the Canadian copper business occurred through ownership changes and joint ventures.

Canadian copper production and shipments increased in 1986 compared to 1985. Production of recoverable copper in concentrates is estimated at 747 000 tonnes (t) in 1986 and could reach 778 000 t in 1987 unless continuing low prices result in further mine closures. Refined production is estimated at 487 000 t in 1986 and is projected to rise to 553 000 t in 1987 providing normal operations resume at Noranda Inc.'s Horne smelter in early-1987.

In 1986, Noranda's CCR refinery was closed, June 4-25, by a strike. At its Horne smelter, workers went on strike on November 5. Consequently, Noranda Inc. declared force majeure on concentrate shipments to the Horne smelter, and on refined shipments in 1987.

CANADIAN DEVELOPMENTS

There were a number of important changes in the structure of the Canadian copper industry in 1986. In July, Lornex Mining Corporation Ltd. and Cominco Ltd. formed Highland Valley Copper, a partnership combining the newer Lornex concentrator and Cominco's Bethlehem concentrator and the Valley orebody. Output at the property is expected to be about 180 000 tpy of copper in concentrates, once modifications are completed in late-1987.

The sale of the Kidd Creek operations in Timmins to Falconbridge Limited was completed in early-1986. Subsequently, Falconbridge Limited sold its interest in Corporation Falconbridge Copper (CFC) to Kerr Addison Mines Limited for $120 million to reduce corporate debt (which in part resulted from the purchase of the Kidd Creek operations). As Kerr Addison is owned 51 per cent by Noranda Inc., Noranda has an interest in copper production from CFC's Opemiska Division and future production from CFC's Ansil project.

In September, Canadian Pacific Enterprises Limited (CPE) announced that it would sell its 52 per cent interest in Cominco Ltd. for $472 million. A holding company comprising 50 per cent Teck Corporation, 25 per cent M.I.M. (Canada) Inc. and 25 per cent Metallgesellschaft Canada Limited purchased 20 million of CPE's 34 million common shares for $205 million in cash and $75 million payable in four years. M.I.M. (Canada) Inc. owns 3.4 per cent of Teck Corporation while a combination of Metallgesellschaft Canada Limited and Metallgesellschaft Canada Investments Limited owns 12 per cent of Teck. Teck Corporation also owns 22 per cent of Lornex Mining Corporation Ltd. which in turn has a 45 per cent interest in Highland Valley Copper.

In **Quebec,** Noranda's Division Mines Gaspé began limited production of development ore from the E-32 orebody. While the underground Needle Mountain mine operated through 1986, the pit has been closed since 1982. Production in 1987 is expected to be 3 000 tpd from the E-32 orebody and 1 500 tpd from the Needle Mountain mine. The smelter operated throughout the year (except for a maintenance shut down), processing concentrates from the mine and foreign sources, principally Chile.

Les Mines Selbaie began initial operations of its A-1 zone open pit zinc-copper mine in October, while continuing operation of the 1 650 tpd underground mine in the B zone copper orebody. The pit should reach rated capacity of 5 000 tpd in early-1987. A feasibility study of the A-2 zone is scheduled to be completed in July 1987. The A-2 orebody could be a replacement for the B zone ore that is likely to be exhausted in mid-1989. At the nearby Matagami Division mine of Noranda Inc., the Isle Dieu zinc orebody was delineated. Close to the

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Mattagami Lake mill, the orebody has a minor amount of copper (1.24 per cent, compared to 18 per cent zinc). A $35 million development progam is under way and sinking of the 670 m shaft should begin in January 1987. The new 2 million t orebody is scheduled to be brought into production in July 1988 with a capacity of 770 tpd, following the likely exhaustion of the Matagami mine in June 1988.

Northgate Exploration Limited continued to reduce its reliance on copper, with only 30 per cent of its revenues derived from copper production in the first half of 1986, compared to 37 per cent in first half of 1985. Campbell Resources Inc. will bring its S-3 mine into production in January 1987. As well, the gold-copper Joe Mann deposit, owned 54 per cent by Campbell Resources, will start production in the second quarter of 1987.

The Corbet mine of the Lac Dufault Division of Corporation Falconbridge Copper was mined out in September. Shaft-sinking at the Ansil deposit continued, reaching a depth of 1 291 m by September 30. Sinking of the ventilation shaft began in October. Development and underground exploration drilling are scheduled to commence in early-1987, with production possible in 1989.

Work at the Mobrun deposit near the former Norbec concentrator, which processed Lac Dufault ore, continued with Audrey Resources Inc. working to earn a half interest in the property. Mining of open pit gold-zinc-copper reserves began in October at a rate of about 25 000 t/month. A 250 m shaft was sunk to facilitate underground exploration to better define the orebody. A final decision on the economics of underground production is expected in June 1987, after milling tests of bulk samples. Estimated cost of the work is $13 to $14 million.

Labour relations difficulties affected operations at Noranda's Horne smelter and CCR refinery. The refinery was closed June 4 to 25 by a strike. The settlement included a signing bonus of $500 and salary increases totalling 75 cents per hour over three years. The average wage prior to the strike was about $13.50 per hour. At the Horne smelter, workers went on strike November 5. The facilities were restarted in the third week of November at a reduced rate using management personnel. Force majeure was declared November 5 on receipts of contracted concentrates from shippers, and in late-November on shipments of refined metal for early-1987.

Noranda's CCR refinery began work on a $19 million slimes treatment plant to be completed in mid-1988. The new plant will have an operating capacity 50 per cent higher than the existing doré furnace.

The **Ontario** mining operations of Inco Limited and Falconbridge Limited in the Sudbury area are reviewed in the nickel chapter of the Yearbook. Inco Limited announced that $15 million would be spent by 1988 on a modernization program at its copper refinery. Areas to be addressed include anode preparation, starter sheet production, the washing and handling of cathodes, and upgrading of slimes handling and electrolyte circulation. This follows a $2 million expenditure for an automated scrap washing and piling system. At Falconbridge's copper refinery in Timmins, the conversion to stainless steel cathode starter blanks was almost completed by year end. Changes in the refinery have resulted in a substantial improvement in the quality of the cathodes. The cathodes are expected to be registered with the London Metals Exchange in 1987 as Grade A quality. The program to expand the smelter to 90 000 tpy, including use of additional oxygen, was completed in 1986. Work is continuing to increase the on-line time which could effectively increase smelting capacity.

In **Manitoba,** the deepening project was completed at the Ruttan mine of Sherritt Gordon Mines Limited. Operating costs were reduced from 86 cents/lb (U.S.) of copper in the third quarter of 1985 to 54 cents in the third quarter of 1986. However, at the end of the year, Sherritt Gordon wrote off the remaining value of the Ruttan mine. The $24.6 million write-down included provision for shutdown costs. The prospect of continuing low copper prices, increasing treatment and refining charges and increasing costs of supplies, services and equipment was noted by the company.

At the Trout Lake mine, owned by Hudson Bay Mining and Smelting Co., Limited (HBM&S), Granges Exploration Ltd., Outokumpu Oy and Manitoba Mineral Resources Ltd., output is scheduled to increase from 0.54 million tpy of ore in 1986 to 0.68 million tpy in 1987. The cut-and-fill mine, with a total staff of 87, is scheduled to produce at 2 720 tpd commencing January 1987.

HBM&S, consulting firms and CANMET (the Canada Centre for Mineral and Energy Technology, Department of Energy, Mines and Resources Canada) continued their joint effort to evaluate a hydrometallurgical process to treat copper concentrates and accurately determine capital and operating costs. The final report, expected in early-1987, will include a financial assessment on implementation of the process at the HBM&S Flin Flon plant.

In **British Columbia,** Noranda decided to continue mining at its Bell mine until the end of 1989, due to better than forecast operational efficiency. A feasibility study on mining the Granisle mine (idle since 1982) and transporting the ore to the Bell mill will be started in 1987.

A mill expansion at Equity Silver Mines Limited was completed in June; the milling rate in the third quarter averaged 9 890 tpd compared with the pre-expansion rate of 5 715 tpd. This allowed a reduction in the mine's cut off grade. Due to the increased milling rate, the life of the reserves has been shortened to about 5 years, approximately to mid-1991. To find additional reserves, an exploration program worth $0.9 million was completed in 1986. Further exploration work is planned for 1987.

Copper cathode production began on October 7 at Gibraltar Mines Limited's new 4 535 tpy solvent extraction and electrowinning (SXEW) plant. The $14 million plant ($3 million less than originally estimated) will treat leach solution from low-grade ore and waste dumps. Operations are scheduled to continue throughout the winter, despite temperatures as low as minus 35°C. Mine production was lower in 1986 than in 1985 due to lower grade, harder ore. The work force was reduced by 55 to 305 at year end. As the operation has lost money since 1981, the company indicated that further changes to the mining plan may be necessary if copper prices fail to improve.

Newmont Mines Limited reached agreement with its union and the provincial government to keep its Similkameen mine in operation, despite financial problems due to low copper prices and lower grade ore. The agreement included a 5 per cent wage reduction and lower hydro-electric rates. The mine is expected to remain in operation until mid-1990.

At the Island Copper mine of Utah International Inc., the mill rate was increased by 3 000 tpd. The expansion decision followed a rate reduction on the extra electrical power required to handle the increased tonnage.

The new mill at Westmin Resources Limited exceeded its 2 720 tpd design capacity, averaging 2 995 tpd in the third quarter. Costs for the first half of 1986 were down 45 per cent from the same period of 1985.

The Highland Valley Copper partnership was officially formed on July 1 by Lornex Mining Corporation Ltd. and Cominco Ltd. Cash requirements and cash generated will be shared 45 per cent by Lornex and 55 per cent by Cominco. A $75 million program, to be completed in late-1987, includes two in-pit crushers worth $17 million, and conveyors to move ore to the Lornex mill. Truck haulage to the Bethlehem mill will continue. The purchase of Cominco stock by the holding company led by Teck Corporation may result in some modifications to the previously announced plan, as Teck may wish to utilize its nearby Highmont mill (which has been closed since October 1984). The Highland Valley Copper operation will produce about 181 000 tpy of copper in concentrates, an increase of 39 000 tpy over the combined output of the two operations in 1985. Truck haulage of ore from the Valley pit to one circuit of the Lornex mill began during the fourth quarter.

Due to potential pit wall instability, mining was accelerated at Afton Mines Ltd. The pit is scheduled to be mined out in early-1987. As the concentrator did not increase production, the extra ore is being stockpiled. In mid-1987, operations are scheduled to commence in the smaller, lower grade Pothook pit on the Afton property.

Plans were announced for further exploration of the gold zone of the Windy Craggy deposit in the northeast corner of British Columbia. Over 1 600 m of drifting and about 3 000 m of diamond drilling are planned for 1987 at an estimated cost of $6 million. In 1983, the deposit was estimated to contain 1 billion t of drill indicated and inferred mineralization grading 1.5 per cent copper and approximately 0.1 per cent cobalt. Some zoning is noted in the deposit, with a gold zone estimated at 2 to 7 million t grading about 9 g/t of gold and 1.2 per cent copper in the centre of the massive sulfides.

Competitiveness

Although Canadian copper producers benefit compared to their U.S. competitors from the from the lower value of the Canadian dollar, U.S. producers secured wage reductions in 1986 in the order of 20 per cent that were not matched in Canada. Nor have Canadian producers benefitted as much from currency devaluations as their competitors in Australia, Chile, Zambia or Zaire.

A substantial proportion of Canadian copper output is produced as a by-product or co-product of other metals such as nickel, gold and zinc. Consequently, the economics of this copper production are greatly influenced by the prices of by-products and co-products as well as by the price of copper.

Continuing low copper prices resulted in relatively few copper mine closures in Canada and in the world in 1985 and 1986, although a number of operations have been unable to cover all costs. Consequently, some have re-designed pits to reduce waste-to-ore ratios which results in reduced ultimate pit sizes and ore reserves.

As development of replacement capacity has not been keeping pace with the mining of reserves, copper production in Canada will eventually fall at currently forecasted prices. However, events such as the re-organization of operations in the Highland Valley could help to offset this decline.

WORLD DEVELOPMENTS

Copper producers in the western world continued to reduce operating costs by operating at higher rates, by rationalizing operations and by reducing wage rates in some cases. Consumers appear to be comfortable with lower stock levels, believing that supply interruptions would likely be short-lived. Consumption in 1987 is forecast to be about 7.4 million t, or slightly higher than the 1985 and 1986 levels of 7.3 million t.

Western world mine production of copper is estimated at 6.6 million t in 1986, up slightly from 6.5 million t in 1985 and is projected to rise to 6.8 million t in 1987. Refined production in 1986 is estimated at 7.3 million t, with an increase to 7.4 million t forecast for 1987. Chile was once again the largest producer of copper at the mine stage. The United States was the largest producer of refined copper.

In the **United States**, mine production of recoverable copper is estimated at 1.17 million t for 1986 and is projected to rise to 1.2 million t in 1987. Refined production is estimated at 1.51 million t in 1986, of which about two-thirds is primary material. Apparent consumption is estimated at 2.17 million t for 1986 and is projected to be 2.2 million t in 1987. United States copper producers negotiated wage and benefits reductions with unions averaging about 20 per cent, without strikes or lockouts. This reduced operating costs by an estimated 4 to 8 cents/lb (U.S.) at the unionized operations.

Four major corporate changes took place in the United States in 1986. ASARCO Incorporated purchased the Ray Unit of Kennecott Corporation, Phelps Dodge Corporation purchased Kennecott's two-thirds interest in Chino Mines Company, Phelps Dodge completed the sale of 15 per cent of the Morenci operations to Sumitomo Metal Mining Arizona Ltd., and Cyprus Minerals Company purchased the Sierrita operation of Duval Corporation.

Phelps Dodge is now the largest U.S. producer, with an effective capacity of about 450 000 tpy of copper. The Chino purchase, involving mining and smelting operations, will offset the closure of its Douglas smelting operation in January 1987 and the depletion of its Tyrone orebody in the early-1990s.

ASARCO's purchase of the Ray operation reduces its dependence on outside concentrates. Ray concentrates have been treated at ASARCO's Hayden smelter since 1983. ASARCO bought Ray for $US 72 million in cash, plus 25 per cent of copper revenues when the Comex spot price is above 68 cents/lb (U.S.) for 10 years to a maximum of $US 65 million.

By selling the Ray and Chino facilities, Kennecott will raise about half of the $US 400 million required for its Bingham modernization project. After wage concessions from its unions, Kennecott announced that limited operations would begin at Bingham prior to the completion of the modernization project scheduled for late-1988. The concentrator is scheduled to start up in early-January 1987. Production for the year is scheduled at 120 000 t of copper. Kennecott's sole production unit is now the Bingham mine.

At the Sierrita mine, Cyprus Minerals Company established a production target of 60 000 t of copper in 1986. A study of a 5 000 tpy SXEW facility was under way. Cyprus signed a ten-year smelting contract with Magma Copper Company to smelt and refine a minimum of 270 000 tpy of concentrating by Magma, starting in 1987.

Following the wage and benefits reduction at Magma Copper Company and the Pinto Valley Copper Corporation, Newmont Mining Corporation announced that it intended to spin off Magma. The Pinto Valley operations, which produced 72 000 t of copper in concentrates and 11 000 t of electrowon cathode in 1985, were merged into Magma. Additionally, Newmont would forgive $US 150 million out of a total of $US 350 million of Magma debts. The debt foregiveness is contingent upon Magma securing financing for working capital for a new 2 722 tpd Outokumpu flash smelter and for expansion of the refinery. The new plan for Magma anticipates a reduction in operating costs from 82 cents/lb (U.S.) in 1986 to about 54 cents/lb in 1989, before interest charges. The cost reductions will be the result of labour concessions, a new underground mining plan and reduced smelter costs at the new smelter. Approval was given for an increase of 50 000 tpy of SXEW production from leaching of the caved portion of the underground orebody. This will be in addition to the 25 000 tpy SXEW facilities that started in May 1986. Newmont would hold 15 per cent of Magma's stock, 80 per cent would be distributed to Newmont shareholders and 5 per cent would be distributed Magma management.

In **Chile**, copper production in 1986 was reported at 0.914 million t in the first eight months of 1986 and is estimated at 1.38 million t for 1986, up about 30 000 t from 1985. Production is forecast at 1.45 million t for 1987. The largest portion of this was accounted for by the world's largest producer, Corporacion Nacional del Cobre de Chile (Codelco-Chile), with estimated production of about 1.1 million t in 1986, up slightly from the 1985 total. At the end of 1986, there was a report that certain previously approved expansion plans of Codelco would be deferred. The expansion of the Chuquicamata Mining Division concentrator from 102 000 tpd to 150 000 tpd by 1988 was to be delayed until 1989. A $US 200 million contract was let for the purchase and installation, by the end of 1989, of two in-pit crushers and conveyors at Chuquicamata to move waste from the pit. A smelter expansion and acid plant are under construction at Chuquicamata; the acid will permit increased leaching of oxide material for additional copper recovery. In the Salvador Mining Division the capacity of the Potrerillos smelter will be increased from 300 000 tpy to 400 000 tpy of concentrates by installing a 200 tpd oxygen plant. This will permit treatment of additional material from Chuquicamata.

Empresa Nacional de Mineria's Las Ventanas refinery reached an estimated capacity of 205 000 tpy in 1986. Production from the refinery was 171 550 t of cathode in 1985. Plans are under review to increase capacity by an additional 100 000 tpy in one or two stages. Acid plants will be built at the Hernan Videla Lira smelter by 1989 and at the Ventanas smelter by 1990.

The Broken Hill Proprietary Company Limited subsidiary, Utah International Inc., reportedly planned to complete necessary financing arrangements by early-1987 to proceed with development of the Escondida property in Chile. Utah International Inc. holds 60 per cent of the property, with 30 per cent held by Rio Tinto-Zinc Corporation Limited and 10 per cent by Mitsubishi Corporation. Outsiders have estimated the operating cost of the $US 1.1 billion project at about 40 cents/lb (U.S.) before financing charges. Estimated production would be about 300 000 tpy of copper in concentrates from the 547 million t orebody grading 2.16 per cent copper.

An agreement between Rio Algom Limited and Outokumpu Oy was announced in early-1986 to develop the Cerro Colorado deposit in Chile as a joint venture. However, disagreement in Finland concerning investments in Chile reportedly caused Outokumpu Oy to withdraw from the proposal joint venture.

In **Zaire**, financial assistance to copper operations is to be provided by the European Investment Bank, which will lend $US 50 million of the $US 790 million required for the rehabilitation plan. The World Bank approved a $US 100 million loan to assist with the modernization of Les Générale des Carrières et des Mines du Zaire (Gécamines) facilities. Part of the 1986-90 modernisation program includes increasing smelting and refining capacity by 100 000 tpy. In November it was reported that Gécamines would receive 41 million European Currency Units to purchase equipment and make transportation improvements.

In **Zambia**, operations of Zambia Consolidated Copper Mines Limited were hindered in 1986 (as in 1985) by the shortage of spares and supplies caused by foreign exchange shortages. Plans were announced to reduce the work force by 20,000 persons (or by one-third) over the next 5 years, as part of a rehabilitation plan. The World Bank will partially fund the rehabilitation plan which also involved closure of some facilities in 1986. The TL 3 SXEW facility was inaugurated in September to recover acid-soluble copper from old tailings. The $US 250 million facility is scheduled to recover an average of 39 300 tpy of copper for the next 15 years.

Zambia examined potential transportation difficulties which could arise from possible sanctions against the Republic of South Africa. The transport of copper from Zambia across RSA and the supply of spare parts to Zambian mining operations could be affected by sanctions. The International Monetary Fund announced in early-1986 that $US 43 million would be loaned to Zambia due to declining export prices. Copper is Zambia's main export. In 1985, copper exports amounted to 79 per cent of total Zambian exports. The loan was linked to currency devaluations, removal of price supports and interest rate controls, and more liberal trade policies.

In **Portugal**, work continued on the Neves-Corvo project, owned 49 per cent by Rio Tinto-Zinc Corporation Limited and 51 per cent by the Portugese government. The $US 200 million project is scheduled to start operations in late-1988. The Corvo and Graca orebodies will be mined at the rate of 1 million tpy to produce about 100 000 tpy of copper in concentrates. Mine planning is based upon a 5 per cent copper cut-off grade. Present reserves total about 27 million t grading 8.5 per cent copper and 40 g/t gold. Additional copper-zinc orebodies are known but are yet to be fully delineated. Subsequent expansion to a mining rate of 3 million tpy has also been studied.

In the **People's Republic of China**, Noranda Inc. and the Tianjin Non-ferrous Metals Industrial Company of China began a joint feasibility study of a 100 000 tpy copper smelter-refinery complex at Tianjin. The study of the $US 200 million project is to be completed in early-1987. A facility at this location would be well situated to process imported concentrates. Chinese imports of copper and copper alloys in the first nine months of 1986 were reported at 103 521 t, sharply lower than the 290 947 t in the same period of 1985.

In **Peru**, the Tintaya mine overcame production difficulties and was operating above rated capacity by year end. Peruvian copper production for 1990 was forecast by the Peru Mining Society as 430 000 t.

In **Mexico**, the 200 000 tpy Outokumpu flash smelter at the La Caridad operations of Mexicana de Cobre S.A. was inaugurated in June. An expansion of the mine and mill is also under way, with about 300 000 t of concentrates grading 32 per cent copper scheduled to be produced in 1986. At the Cananea mine, the concentrator is being expanded in steps, with capacity of the mine and mill scheduled to increase by 100 000 tpy of copper in concentrates to 150 000 tpy. Mexican copper production was forecasted as 320 000 tpy by the end of the decade, compared with 179 001 t in 1985.

In **Brazil**, development of the Salobo copper-gold deposit owned by Cia Vale do Rio Doce was planned. A $US 600 million complex is envisaged which would produce 120 000 tpy of copper in concentrates. An important consideration in the development of the deposit is the gold content of the ore, averaging 10 to 15 g/t. Cia Paraibuna de Metais SA announced plans to construct a $US 250 million smelter and refinery that would produce 100 000 tpy of refined copper from the Salobo deposit. This would provide competition for the Caraiba Metais S.A. - Industria e Comércio smelter/refinery complex. Caraiba Metais planned production of 120 000 t of refined metal in 1986, part of which came from the new underground mine at Jaguarari.

In **Australia**, a contract was awarded for phase I of the Olympic Dam uranium-copper-gold project. The total cost is estimated at $A 750 million, including $A 40 million for a copper refinery. Copper production is scheduled to commence in mid-1988 at 30 000 tpy of refined metal. Once a second shaft is developed and a second 1.5 million tpy concentrator module is started up, refined copper production will increase to 55 000 tpy. The timing of this expansion will be determined by future uranium and copper prices, but is expected to take place in the early-1990s. Construction of a $A 6 million Isasmelt demonstration plant for copper started at the Mount Isa operations of M.I.M. Holdings Limited. This will increase smelting capacity. The mine had been producing about 80 000 tpy more copper concentrates than the existing smelter could handle, and the excess production was exported. The Isasmelt process is a submerged lance combustion technology that was developed by the Commonwealth Scientific and Industrial Research Organization in Australia.

In **Papua New Guinea,** the Ok Tedi mine will begin shipments of copper concentrates in 1987. Ore grades from the copper zone are expected to average between 1.5 and 2 per cent copper in the initial phases. Production of 200 000 t of copper concentrates grading 30 to 35 per cent copper in 1987 and 600 000 t in 1988 or 1989 is expected. A prefeasibility study for a copper smelter was begun for Ok Tedi material and potentially some custom concentrates. The study is evidently a response to higher charges proposed by existing smelters.

In **Japan,** the large appreciation of the yen exacerbated existing problems for the country's smelting and refining industry. As smelting and refining charges are in U.S. dollars and local costs are in yen, the financial performance of Japanese smelters seriously deteriorated in 1986. Some new contracts provide for increased treatment and refining charges (TC/RCs) as the value of the yen increases. Other mines were approached by Japanese smelting and refining companies for increases in TC/RCs. The ability of the Japanese smelting and refining industry to increase these charges is restricted by the continuing financial difficulties of concentrate exporters caused by low copper prices. Nevertheless, TC/RCs in U.S. currency have risen compared to 1985, and rates would likely increase further should the Escondida project in Chile proceed.

Japanese production and consumption of copper in calendar 1986 are estimated at 0.935 million t and 1.225 million t, respectively. The forecasts for production and consumption in calendar 1987 are 0.935 million t and 1.34 million t. Domestic smelting and refining capacity is about 1.24 million tpy.

Elsewhere, events in the copper industry included: approval of the takeover of the Viscaria mine in Sweden by Outokumpu Oy; the possible reactivation of Kennecott Corporation's idled refinery and rod mill in Baltimore to process blister copper from Corporacion Nacional del Cobre de Chile; the prolongation of operations at Prieska mine in South Africa to the end of 1987 due in part to the devaluation of the rand; Phelps Dodge Corporation's sale of half of its 49 per cent interest in the Cayeli copper deposit in Turkey to Metallgesellschaft AG; cost cutting at Boliden AB's operations involving the layoff of 1,500 of 8,000 persons to reduce losses (estimated costs at the Atik copper mine will be reduced to 54 from 55 cents/lb (U.S.) by February 1987); the possibility that the Ronnskar copper smelter in Sweden, which produced over 90 000 t of copper in 1985, might be closed if forced to make major anti-pollution investments.

PROPOSED INTERNATIONAL COPPER ORGANIZATION

In December, a meeting was held in Geneva to discuss a U.S. proposal for a producer-consumer forum on copper, akin to the International Lead and Zinc Study Group. Further discussions will be held in 1987 to explore the feasibility of establishing such a group for copper.

PRICE AND EXCHANGES

The London Metal Exchange (LME) settlement price for the highest grade of copper averaged 62.3 cents/lb (U.S.) in 1986. This compares with an average of 64.9 cents in 1985. The Commodity Exchange, Inc. (Comex) price for copper averaged 61.65 cents/lb (U.S.) in 1986, compared with 61.0 cents in 1985. The average monthly LME and Comex prices for 1985 and 1986 are shown in Table 7.

The LME changed the highest grade copper contract, effective the end of June. The majority of wirebar brands were eliminated from the new grade A contract. The eliminated wirebar brands and the lower grade cathodes are deliverable against a standard contract.

The Japanese Electric Wire & Cable Makers Association has asked the government to investigate the possibility of setting up a terminal market for copper in Japan. The proposal was being studied by the end of the year.

STOCKS

Combined LME plus Comex stocks declined during 1986 from 297 000 t to 256 700 t. Commodities Research Unit Ltd. (CRU) estimated in December that exchange and industry stocks were below the former trigger point of 9 weeks of production that previously would have led to significant price rises. As no such price rise occurred, CRU concluded that the trigger level has changed, likely due to consumers' belief that copper shortages are unlikely.

USES

Copper is the preferred material when superior electrical or thermal conductivity and corrosion resistance is desired. Copper's electrical conductivity is over 60 per cent greater than that of aluminum and its thermal conductivity is over 75 per cent higher. Hence copper's main uses are in the transmission of electrical energy and electrical signals, water transmission and for heat transfer.

Copper is therefore one of the basic necessities for the development and maintenance of the infrastructure of both developing and developed countries.

OUTLOOK

Consumption of refined copper is expected to increase slightly to 7.4 million t in 1987 compared to an estimated 7.3 million t in 1986. Forecasts generally call for average growth rates of 1 to 1.5 per cent per year. Thus, consumption is expected to be in the range of 7.7 to 8.0 million t in 1990 and about 9.4 million t by the end of the century.

Higher growth rates in the 1990s are based on the assumption that debt of certain developing countries will be more manageable than in the 1980s. This will permit these countries to increase investment in copper-intensive infrastructure and capital goods. The chairman of CRA Limited noted that world infrastructure has been allowed to run down in the last 25 years due to insufficient investments for maintenance. Increased infrastructure investments will increase copper demand.

Relatively few new uses are being developed for copper. The decision by Corporacion Nacional del Cobre de Chile to join the International Copper Research Association should give an impetus to research and development and product promotion. Shortly after assuming office the new president of Corporacion Nacional del Cobre de Chile spoke of the need to increase the consumption of copper.

Copper prices have been essentially independent of the rate of inflation since 1965. This is seen from an examination of copper prices denominated in Special Drawing Rights (SDRs) of the International Monetary Fund. Copper prices usually varied within the range of 0.5 to 0.7 SDR/lb between 1965 and 1986. At the December 1 value of the U.S. dollar, this range translated into a range of 60 to 85 cents/lb (U.S.). It should be noted that these prices are in the dollars of the day, not in constant dollars.

Copper is now being used more effectively than in the past. Fewer kilograms of copper are now required to perform the same function due to such technological advances as multiplexing of communications signals, capillary joints for tubing and the use of high strength, thin wall tubing. While such advances reduce copper usage in individual installations, the cost savings (by using the copper more effectively) mean that copper remains the economical choice, and so copper is less prone to substitution.

The average price of Grade A copper on the LME is forecast to be 62 cents/lb (U.S.) in 1987. Supply interruptions or changes in output could result in temporarily higher prices, depending upon their perceived seriousness and duration. Potential examples of supply interruptions or changes include sanctions against South Africa which would reduce copper shipments from Zambia and Zaire or their imports of machinery and supplies, and further delays in the expansion program of Corporacion Nacional del Cobre de Chile.

Despite production cost cutting worldwide, some increase in copper prices is needed to justify the future investments in copper necessary to meet the forecast demand in the 1990s. Many mines have reduced recoverable ore reserves by cutting waste-to-ore ratios to reduce operating costs. The necessary investment to replace depleting production capacity can rarely be justified at present copper prices. Demands by Japanese and other smelters for higher treatment and refining charges likely will reduce the incentive for new investment unless the price of copper increases.

Accordingly, copper prices are expected to rise modestly over the next few years, with the annual average LME price reaching 72 cents/lb (U.S.) by the early-1990s (in current dollars) as present orebodies are mined out. Thereafter, assuming no serious acceleration in inflation rates, current dollar prices are expected to fluctuate around the 72 cent level and tend to remain at that level for the rest of the decade. New technological methods are expected to continue to reduce the operating and capital costs of producing copper, counteracting the inflation of input costs. Such cost reductions are a necessary response to competitive pressures in the market, where substitute materials are readily available if copper prices rise too high.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
CANADA					
32900-1	Copper in ores and conc.	free	free	free	free
33503-1	Copper oxides	free	12.8	25.0	free
34800-1	Copper scrap, matte and blister and copper in pigs, blocks or ingots; cathode plates of electrolytic copper for melting, per lb	free	free	1.5¢	free
34820-1	Copper in bars or rods, when imported by manufacturers of trolley, telegraph and telephone wires, and electric wires and electric cables, for use only in the manufacture of such articles in their own factories	free	4.3	10.0	free
34835-1	Electrolytic copper powder electrolytic iron powder, for use in Canadian manufactures (expires June 30, 1986)	free	free	10.0	free
34845-1	Electrolytic copper wire bars, for use in Canadian manufactures per lb (expires June 30, 1986)	free	free	1.5¢	free
35000-1	Anodes of copper	free	free	10.0	free
MFN Reductions under GATT (effective January 1 year given)			1986	1987	
			(%)		
33503-1			12.8	12.5	
34820-1			4.1	4.0	
UNITED STATES (MFN)					
602.30	Copper, ores etc.		Remains free		
612.02	Unwrought copper, etc.		1.7	1.7	
612.08	Copper waste and scrap		2.9	2.4	
EUROPEAN ECONOMIC COMMUNITY (MFN)		1986		Base Rate	Concession Rate
26.01	Copper, ores and conc.	free		free	free
74.01	Copper in matte, unwrought copper, waste and scrap	free		free	free
JAPAN (MFN)					
26.01	Copper, ores and conc.	free		free	free
74.01	(1) Copper in matte etc.	free		free	free
	(2) Copper, unwrought				
	(a) containing not more than 99.8% by weight of copper etc.	7.5		8.5	7.3
	(b) Other				
	(i) Containing by weight, not less than 25% of zinc and not less than 1% of lead	16.13 yen/kg		24 yen/kg	15 yen/kg
	(ii) Containing more than 95% by weight of copper				
	- blister copper in bar	7.5		8.5	7.3
	- other	21.38 yen/kg		24 yen/kg	21 yen/kg
	(iii) Containing not more than 95% by weight of copper	21.38 yen/kg		24 yen/kg	21 yen/kg
	(3) Waste and scrap				
	(a) Unalloyed	0.3		2.5	free
	(b) Other: containing more than 10% by weight of nickel	2.8		22.5	free
	(c) Other	0.3		2.5	free

Sources: The Customs Tariff, 1986, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated (1986), USITC Publication 1775; U.S. Federal Register Vol. 44, No. 241; Official Journal of the European Communities, Vol. 28, No. L331, 1986; Customs Tariff Schedules of Japan, 1986; GATT Documents, 1979.

TABLE 1. CANADA, COPPER PRODUCTION, TRADE AND CONSUMPTION, 1984-86

	1984r		1985p		1986e	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Shipments[1]						
British Columbia	280 638	530,968	299 560	594,926	332 084	677,783
Ontario	292 220	552,879	284 692	565,398	289 297	590,456
Quebec	67 537	127,781	69 071	137,175	69 274	141,389
Manitoba	67 618	127,933	73 531	146,032	67 045	136,840
New Brunswick	7 800	14,757	6 774	13,454	7 068	14,427
Saskatchewan	4 798	9,078	4 976	9,882	3 455	7,051
Newfoundland	0	0	10	19	20	41
Yukon	69	130	23	46	0	1
Northwest Territories	1 146	2,169	0	0	0	0
Total	721 626	1,365,695	738 637	1,466,932	768 243	1,567,988
Refinery output	504 262	..	499 626	..	487 000	..
Exports					(Jan.-Sept.)	
Copper in ores, concentrate and matte						
Japan	222 285	280,808	216 689	311,226	177 654	263,141
People's Republic of China	8 080	10,919	16 026	26,488	21 311	31,125
Norway	26 100	38,424	25 365	40,920	15 598	25,618
Taiwan	21 094	28,248	29 582	40,690	12 012	18,620
South Korea	37 473	45,071	4 415	6,481	10 878	16,240
United States	15 099	19,267	594	74	2 443	3,786
United Kingdom	825	1,531	897	1,630	594	1,075
Belgium-Luxembourg	246	165	1 005	610	932	522
Mexico	507	584	0	0	0	0
Bermuda	510	590	0	0	0	0
Brazil	2 018	2,266	2 355	3,266	0	0
Portugal	685	689	0	0	0	0
Italy	91	43	0	0	0	0
West Germany	2 694	3,287	0	0	0	0
India	35	60	0	0	0	0
Switzerland	1 082	1,569	0	0	0	0
Sweden	16	20	0	0	0	0
Total	339 040	433,546	296 928	311,226	241 422	360,126
Copper in slag, skimmings and sludge						
Italy	0	0	322	152	250	100
United States	2 755	1,118	3 449	951	1	7
Total	2 755	1,118	3 771	1,103	251	107
Copper scrap (gross weight)						
United States	28 242	42,298	26 094	39,148	23 319	39,810
West Germany	722	1,051	2 980	4,740	7 327	8,703
Other countries	3 512	5,056	10 463	14,901	4 256	6,330
Total	32 476	48,405	39 537	58,789	34 902	54,843
Brass and bronze scrap (gross weight)						
United States	11 460	15,459	9 215	11,227	9 169	11,641
Italy	849	1,066	1 849	2,261	1 436	1,789
West Germany	320	471	1 908	2,364	746	1,054
Brazil	0	0	40	46	503	1,040
Taiwan	992	1,222	475	573	720	859
Other countries	1 687	2,017	2 760	3,367	2 242	2,523
Total	15 308	20,235	16 247	19,838	14 816	18,906
Copper alloy scrap, nes (gross weight)						
United States	3 944	4,644	4 311	4,224	4 380	4,525
Other countries	771	991	2 378	2,950	1 005	1,047
Total	4 715	5,635	6 689	7,174	5 385	5,572
Copper refinery shapes						
United States	185 625	383,768	135 488	258,792	143 628	285,673
United Kingdom	39 840	727,020	41 346	79,492	41 381	81,156
West Germany	24 540	43,764	18 151	34,246	11 800	23,497
Netherlands	15 981	28,963	25 060	42,733	7 226	13,531
Italy	4 665	8,253	4 306	8,151	6 337	12,878
People's Republic of China	38 528	67,642	24 063	40,921	2 500	4,930
Other countries	36 816	66,411	28 701	55,195	15 801	30,083
Total	345 985	631,521	277 115	519,528	228 713	451,748
Copper bars, rods and shapes, nes						
United States	9 420	23,706	11 549	27,780	10 841	25,908
Bangladesh	2 787	5,292	1 544	3,137	1 451	3,135
Venezuela	2 773	5,861	1 303	2,765	1 295	2,902
Other countries	7 412	14,349	5 074	10,248	1 926	4,220
Total	22 392	49,208	19 470	43,930	15 513	36,165

TABLE 1. (cont'd.)

	1984ʳ		1985P		(Jan.-Sept.) 1986	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Copper plates, sheet and flat products						
United States	6 025	19,335	4 802	16,173	2 985	10,077
Other countries	219	716	3 504	6,433	105	384
Total	6 244	20,051	8 306	22,606	3 090	10,461
Copper pipe and tubing						
United States	4 962	14,618	4 816	14,391	4 466	13,685
Israel	1 016	2,695	707	1,954	385	1,142
Other countries	564	1,694	154	466	204	878
Total	6 542	19,007	5 677	16,811	5 055	15,705
Copper wire and cable (not insulated)						
United States	487	1,048	196	623	273	791
Mexico	0	0	18	433	127	280
Other countries	167	519	150	189	151	277
Total	654	1,567	364	1,245	551	1,348
Copper alloy shapes and sections						
United States	19 122	53,480	12 928	36,822	12 397	30,032
Other countries	120	443	98	274	12	95
Total	19 242	53,923	13 026	37,096	12 409	30,127
Copper alloy pipe and tubing						
United States	5 085	14,821	3 612	12,884	1 387	6,470
Other countries	42	128	79	243	30	154
Total	5 127	14,949	3 691	13,127	1 417	6,624
Copper alloy wire and cable, not insulated						
United States	379	807	327	898	107	452
Other countries	34	217	13	91	30	129
Total	413	1,024	340	989	137	581
Copper and alloy fabricated materials, nes						
United States	1 759	5,919	1 306	4,943	691	3,366
United Kingdom	746	1,314	128	254	11	93
Other countries	185	646	206	544	230	803
Total	2 690	7,879	1 640	5,741	932	4,262
Total exports of copper and products	..	1,308,069	..	1,179,342	..	996,576
Copper Imports						
Copper in ores and concentrates	36 222	34,672	76 177	66,198	51 166	54,955
Scrap	66 530	76,347	77 749	90,928	48 390	62,863
Refinery shapes	25 564	48,751	19 131	39,409	13 771	29,013
Bars, rods and shapes, nes	5 107	11,087	5 656	12,583	3 550	8,493
Plates, sheet and flat products	4 975	14,139	4 820	13,494	2 183	6,655
Pipe and tubing	3 086	10,751	3 433	12,091	1 979	7,291
Wire and cable, not insulated	3 424	12,600	3 950	15,338	2 814	11,329
Alloy scrap (gross weight)	9 807	11,032	7 454	8,780	4 893	5,834
Powder	1 101	2,805	747	1,919	799	1,916
Alloy refinery shapes, bars	12 366	31,244	11 436	28,585	9 347	24,080
Brass plates, sheet, strip, etc.	4 166	13,025	4 002	12,836	4 402	14,263
Alloy plates, sheet, etc. nes	1 769	8,226	1 638	7,705	1 180	6,413
Alloy pipe and tubing	4 107	19,313	3 765	17,937	3 763	18,239
Alloy wire and cable not insul.	1 277	4,297	1 506	5,061	1 091	3,633
Copper and alloy fab. mat., nes	2 129	11,707	2 732	13,836	2 446	12,239
Insulated wire and cable	..	168,825	..	129,344	..	103,907
Oxides and hydroxides	236	576	270	759	345	886
Sulphate	2 642	1,751	1 381	1,102	3 126	2,469
Alloy castings	694	4,483	551	3,616	576	3,591
Valves, brass nes	..	22,176	..	25,765	..	19,589
Pipe fittings copper and copper alloy	..	17,613	..	18,129	..	14,892
Total imports of copper and products[3]	185 122	525,420	226 398	525,415	155 821	410,550
Producers' domestic shipments					1986ᵉ	
Refined	205 476	..	203 335	..	205 000	..

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Blister copper plus recoverable copper in matte and concentrate exported; totals may not add due to independent rounding. [2] Includes small quantities of non-copper wire and cable, insulated. [3] Total imported tonnage does not include insulated wire and cable, valves or pipe fittings.

.. Not available or not applicable; nes Not elsewhere specified; P Preliminary; ʳ Revised; ᵉ Estimated.

TABLE 2. CANADA, COPPER PRODUCTION, TRADE AND CONSUMPTION, 1970, 1975 AND 1980-86

	Production		Exports			Imports	Consumption[2]
	Shipments[1]	Refinery Output	Concentrates and Matte +	Refined =	Total	Refined	Refined
				(tonnes)			
1970	610 279	493 261	161 377	265 264	426 641	13 192	229 026
1975	733 826	529 197	314 518	320 705	635 223	10 908	196 106
1980	716 363	505 238	286 076	335 022	621 098	13 466	208 590
1981	691 328	476 655	276 810	262 642	539 452	24 778	241 537
1982	612 455	337 780	257 930	232 621	490 551	28 028	158 587
1983	653 040	464 333	313 796	298 528	612 324	24 559	195 002
1984[r]	721 826	504 262	332 373	345 985	685 032	25 563	231 039
1985[p]	738 637	499 626	296 928	277 115	574 043	19 131	222 466
1986[e]	768 000	487 000	241 422[3]	228 713[3]	470 135[3]	13 771[3]	167 137[3]

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Blister copper plus recoverable copper in matte and concentrate exported. [2] Producers' domestic shipments of refined copper plus imports of refined shapes. [3] January to September 1986 data.
[p] Preliminary; [e] Estimated; [r] Revised.

TABLE 3. WESTERN WORLD MINE PRODUCTION OF RECOVERABLE COPPER IN CONCENTRATES, 1985, 1986 AND 1987

	1985	1986[e]	1987[f]
		(000 tonnes)	
Chile	1 355	1 378	1 450
United States	1 106	1 170	1 200
Canada[1]	730	747	778
Zambia	479	490	530
Zaire	502	500	505
Peru	385	400	390
Australia	261	250	250
Philippines	226	225	225
South Africa	204	200	200
Papua New Guinea	179	180	240
Other	1 073	1 060	1 032
Total western world	6 500	6 600	6 800

Sources: World Bureau of Metal Statistics, U.S. Bureau of Mines, and Energy, Mines and Resources Canada, private communications, Brook Hunt and Associates.
Data as available January 12, 1987.
[1] Shipments.
[e] Estimated; [f] Forecast.

TABLE 4. WESTERN WORLD PRODUCTION OF REFINED COPPER[1],[2] 1985 AND 1986

	1985	1986[e]
	(000 tonnes)	
United States	1 435	1 510
Japan	935	935
Chile	884	928
Zambia[3]	500	510
Canada[4]	500	487
Belgium	413	415
Germany, Federal Republic	414	425
Zaire	227	215
Other	2 022	2 005
Total western world	7 330	7 430

Sources: World Bureau of Metal Statistics, U.S. Bureau of Mines, Energy, Mines and Resources Canada, private communications, Brook Hunt and Associates
Data as available January 12, 1987.
[1] Includes primary, secondary and electrowon copper. [2] Includes Yugoslavia. [3] Includes material from Zaire. [4] Strike at Noranda refinery June 4-25 and at Noranda's Horne Smelter November 5 through end of 1986 into 1987.
[e] Estimated.

TABLE 5. CANADIAN COPPER AND COPPER-NICKEL SMELTERS, 1986

Company and Location	Product	Rated Annual Capacity	Blister or Anode Copper Produced in 1985[1]	Remarks
		(tonnes of ores and concentrates)	(tonnes)	
Falconbridge Limited Falconbridge, Ont.	Copper nickel matte	570 000	26 800	A smelter modernization program begun in 1975 was completed in 1978 at a cost of $79 million. Fluid bed roasters and electric furnaces replaced older smelting equipment. A 1 800 tpd sulphuric acid plant treats roaster gases. Matte from the smelter is refined in Norway.
Inco Limited Sudbury, Ontario	Molten "blister" copper, nickel sulphide and nickel sinter for the company's refineries; nickel oxide sinter for market, soluble nickel oxide for market	3 630 000[2]	119 800*[3]	Oxygen flash-smelting of copper concentrate; converters for production of blister copper. Roasters, reverberatory furnaces for smelting of nickel-copper concentrate, converters for production of nickel-copper Bessemer matte. Production of matte followed by matte treatment, flotation, separation of copper and nickel sulphides, then by sintering to make sintered-nickel products for refining and marketing. Electric furnace melting of copper sulphide and conversion to blister copper.
Falconbridge Limited, Timmins, Ontario	Molten "blister" copper	under expansion	70 000*	Mitsubishi-type smelting, separation and converting furnaces, acid plant and oxygen plant to treat continuous copper concentrate feed stream to yield molten 99 per cent pure copper which is transported by ladles and overhead cranes to two 350 t anode furnaces. Expansion plans to 90 000 tpy by 1988 announced in 1984 was essentially completed by end of 1986.
Noranda Inc. Horne smelter, Noranda, Que.	Copper anodes	838 000	186 000	One oxy-fuel fixed reverberatory furnace; five converters; 1 continuous Noranda Process reactor; oxygen for the reverberatory furnace and Noranda reactor are supplied by two plants with a combined total of 540 tpd. Continuous reactor modified to produce matte instead of metal.
Noranda Inc. Gaspé smelter, Murdochville, Que.	Copper anodes	325 000	43 500	Equipped with one fluid bed roaster, one reverberatory furnace and two converters plus an acid plant. Treats Gaspé and custom concentrates.
Hudson Bay Mining and Smelting Co., Limited Flin Flon, Man.	Copper anodes	400 000	66 000	Five roasting furnaces, one reverberatory furnace and three converters. Company treats its own copper concentrate from mines at Flin Flon and Snow Lake, as well as custom copper concentrates, zinc plant residues and stockpiled zinc-plant residues fed to reverberatory furnace.

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[1] Smelter output as reported in corporate annual reports; if no smelter data available, then refinery output shown and indicated by * following number. [2] Includes copper and nickel-copper concentrates. This capacity cannot be fully utilized owing to Ontario government sulphur dioxide emission regulations. [3] Includes a small tonnage of copper from Inco's Manitoba operations.

TABLE 6. COPPER REFINERIES IN CANADA, 1986

Company and Location	Rated Annual Capacity	Output in 1985[1]	Remarks
	(tonnes)		
Noranda Inc. Division CCR East Montreal, Quebec	435 000	304 800	Refines anodes from Noranda's Horne and Gaspé smelters, from the Flin Flon smelter and also from purchased scrap. Copper sulphate and nickel sulphate recovered by vacuum evaporation. Precious metals, selenium and tellurium recovered from slimes. Produces CCR brand electrolytic copper cathodes and cakes and billets. $19 million program to construct new slimes treatment plant announced in 1986 to be completed by mid-1988.
Inco Limited Copper Cliff, Ont.	180 000	119 800	Casts and refines anodes from molten converter copper from the Copper Cliff smelter; also refines purchased scrap. Gold, silver, selenium and tellurium recovered from anode slimes, along with platinum metals concentrates. Recovers and electrowins copper from Copper Cliff nickel refinery residue. Produces ORC brand electrolytic copper cathodes, and wirebars. Modernization program began in 1986.
Falconbridge Limited Timmins, Ontario	(See Note)	70 000	Molten copper from two 350 t anode furnaces is cast in a Hazelett continuous casting machine into continuous copper strip, then formed to 145 kg anodes in a blanking press. Spent and scrap anodes are remelted in a 40 t ASARCO shaft furnace. Cathodes formed in jumbo sized electrolytic tanks in a highly automated tankhouse. A decopperized precious metal slime is also marketed. Switch-over to stainless steel blanks for cathodes growth almost completed by end of 1986. Note: Expansion to 90 000 tpy by 1988 under way since 1984.

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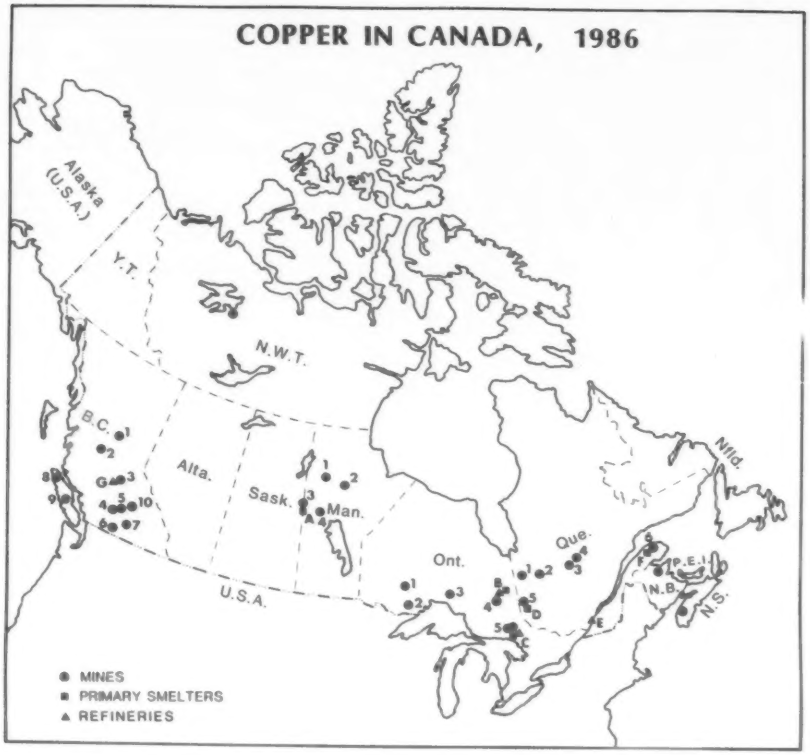
[1] As reported in corporate annual reports or as advised by company.

TABLE 7. AVERAGE COPPER PRICES
(LME Settlement Prices for Higher Grade Copper, 1985 and Jan. 1 - June 30, 1986, thereafter Grade A) (Comex Copper Prices - first position)

	LME		Comex	
	1985	1986	1985	1986
	(current cents/lb. (U.S.))			
January	61.6	64.3	59.2	65.3
February	63.0	63.8	60.6	63.9
March	63.0	65.5	60.1	66.0
April	68.1	65.1	63.6	63.8
May	69.4	64.4	62.9	62.7
June	65.0	64.1	60.1	62.6
July	66.9	61.0	60.8	58.9
August	64.4	59.1	60.2	57.6
September	62.0	61.1	59.6	60.7
October	62.8	59.7	61.0	59.2
November	62.1	59.1	60.6	58.9
December	63.2	60.6	63.2	60.2
Annual	64.9	62.3[1]	61.0	61.5

Source: Metals Week except LME 1986 annual average.

[1] Not calculated by Metals Week, as neither Grade A or higher grade contracts existed throughout the entire year. The arithmetic average of the monthly prices for the highest grade sold calculated as 62.3 cents/lb., (U.S.).



COPPER IN CANADA, 1986

Alaska (U.S.A.)
Y.T.
N.W.T.
B.C.
Alta.
Sask.
Man.
Ont.
Que.
Nfld.
P.E.I.
N.B.
N.S.
U.S.A.
● MINES
■ PRIMARY SMELTERS
▲ REFINERIES

PRODUCERS IN 1986

(numbers and letters correspond to those in map "Copper in Canada 1986")

British Columbia

1. Noranda Inc. (Bell mine)
2. Equity Silver Mines Limited
3. Gibraltar Mines Limited
4. Lornex Mining Corporation Ltd.[1]
5. Cominco Ltd.[1]
6. Newmont Mines Limited
7. Brenda Mines Ltd.
8. Utah Mines Ltd.
9. Westmin Resources Limited
10. Afton Mines Ltd.

Saskatchewan

Hudson Bay Mining and Smelting Co., Limited

Manitoba

1. Sherritt Gordon Mines Limited (Ruttan mine)
2. Inco Limited (Thompson mine)
3. Hudson Bay Mining and Smelting Co., Limited, Flin Flon area mines
4. Hudson Bay Mining and Smelting Co., Limited, Snow Lake area mines

Ontario

1. Mattabi Mines Limited
   Noranda Inc. (Lyon Lake)
2. Inco Limited (Shebandowan mine)
3. Noranda Inc. (Geco mine)
4. Falconbridge Limited, Timmins
   Pamour Inc.
5. Falconbridge Limited, Sudbury area
   Inco Limited, Sudbury area

Quebec

1. Les Mines Selbaie
2. Noranda Inc. (Mattagami Lake mine)
3. Corporation Falconbridge Copper, Opemiska Division
4. Northgate Mines Inc.
   Campbell Resources Inc.
5. Corporation Falconbridge Copper, Lac Dufault Division
   Audrey Resources Inc. (Mobrun project)
6. Noranda Inc., Division Mines Gaspé

New Brunswick

Brunswick Mining and Smelting Corporation Limited

Nova Scotia

Rio Algom Limited

SMELTERS

A. Hudson Bay Mining and Smelting Co., Limited
B. Falconbridge Limited
C. Inco Limited
   Falconbridge Limited
D. Noranda Inc.
F. Noranda Inc., Division Mines Gaspé

REFINERIES

B. Falconbridge Limited
C. Falconbridge Limited
   Inco Limited
E. Noranda Inc., Division CCR
G. Gibraltar Mines Limited

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[1] Operations combined as Highland Valley Copper, a partnership of Cominco Ltd. and Lornex Mining Corporation Ltd.

An inventory of undeveloped Canadian copper deposits is available in the publication "Canadian Mineral Deposits Not Being Mined in 1983", Energy, Mines and Resources Canada, Report MRI 198, ISBN 0-660-11580-8.

For detailed production and ore grade information, refer to the Table of Nonferrous Mines following the last commodity chapter.

Crude Oil and Natural Gas

R.L. THOMAS

The dramatic drop in global oil prices in 1986 has depressed exploration and development activities in Canada. During the past 14 years, the world has witnessed three price "shocks" that have had an impact on producers and consumers of crude oil and related products. The first occurrence, in 1973, saw the increase in importance of the role of the Organization of Petroleum Exporting Countries (OPEC) formed in 1960 and a jump in crude oil prices. This resulted in several consumer nations starting conservation schemes necessary to curtail the volumes of high-cost imported oil. The next price escalation came in 1979 with a further doubling of oil prices until 1982 during which time OPEC prices began to shift downward due to a world recession. At the commencement of 1986, the oil price dropped markedly to one half of its 1985 level and stabilized to about $US 14 per barrel. In Canada, the current price for oil has not only slowed major projects in oil sands, heavy oils and frontier offshore development, but also for conventional drilling in the western provinces. Canadian well completions are anticipated to reach 6,500 this year, which represents a 46 per cent decrease compared to last year's record level of 12,000 completions. Aggregate metrage drilled is expected to be 9 million m whereas it was 13.7 million m in 1985, a decline of 34 per cent. Although drilling and metrage are down, these statistics indicate that the average well depth has increased from 200 m to 1 380 m/well.

EXPLORATION

Statistics compiled for the first three quarters of 1986 show the level of exploration activity in western Canada (Manitoba, Saskatchewan, Alberta, and British Columbia) has declined considerably compared to the corresponding period last year. Late last year, it was realized that 1985 would be a record year, especially for drilling activity, and industry analysts at that time were forecasting that 1986 would surpass that level by some 1 500 wells. Although oil prices had fallen earlier this year, the drilling industry achieved almost 3,609 well completions during the first three months. This was 20 per cent higher than the 3,000 wells drilled in the first quarter of 1985. In the January-to-March period, activity in the western provinces is normally high because the ground is frozen, thus permitting the movement of heavy equipment and making drilling much easier. In April of each year, the western provincial governments impose "road bans" that restrict heavy vehicles from many of the highways because of ground thaw. This change in weather conditions may last from six to eight weeks during which time very little exploration activity occurs. After this lull in activity, known as Spring breakup, the petroleum industry begins summer drilling first in the southern regions, then quickly moving northward.

This year, the traditional surge in activity after breakup did not occur due to dropping oil prices. There has been a marked decline in all upstream indicators, such as: land sales, geophysical activity, well licences, and rig utilization. In western Canada, revenues received by the provincial governments have fallen by 70 per cent, from $755 million in 1985 to $224 million, and the number of hectares (ha) sold is down by 40 per cent, from 2.9 million ha to 1.7 million ha. The average price paid per ha, having declined by 48 per cent, went from $261 per ha to $135 per ha.

While last winter some 112 geophysical crews were active, there are now only 55 active crews. The geophysical sector has experienced a serious downturn during the past couple of years. Geophysical companies bidding for available contracts are often operating at costs. Some of the older established firms have restructured or ceased operations due to rising costs, carried debt and reduced cash-flow. Many operators, in order to reduce risks, are restricting exploration to known oil and gas regions where there already exists basic geophysical information. This in turn reduces the need for extensive new surveys.

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The number of well licences issued, a provincial requirement for drilling wells, has also fallen drastically. Down by more than 50 per cent, this statistic is a leading indicator for the number of future completions. At the end of September 1986, the western provinces had issued some 4,200 licences compared to almost 8,700 licences issued during the same period the previous year.

The utilization rate for Canada's drilling rigs has not yet fully recovered to its normal level since spring breakup. Its fleet availability remains the same as last year at around 560 units, but only 150 rigs are active for 30 per cent utilization, whereas during the corresponding 1985 period, some 350 rigs were employed. In the remaining quarter of this year, an improvement in rig utilization is anticipated due to the winter drilling season, provincial incentives and the removal of a federal tax (PGRT) which will improve company cash flows.

RESERVES

At the commencement of 1986, Canada's total remaining established reserves of crude oil and pentanes plus stood at 1 068 million m^3, a slight improvement over 1985. In the producing regions, south of 60° latitude, the reserves of conventional crude oil fell by 12 million m^3 to 804 million m^3; pentanes plus had risen by 34 million m^3 to 134 million m^3, resulting in a net increase in reserves of 2 per cent, or 22 million m^3 to 938 million m^3. Frontier reserves of crude and pentanes plus declined by 21 million m^3 to 130 million m^3 due to reassessment.

An increase of 34 million m^3, to 169 million m^3, was recorded in the reserves of liquefied petroleum gases during the past year. All of the increase occurred in western Canada and primarily in Alberta. In Manitoba, there was a six-fold increase in LPG reserves, which went from 13 to 77 thousand m^3, due to increased drilling for natural gas. Saskatchewan's reserves dipped slightly because of increased natural gas production.

Canada's remaining established reserves of marketable natural gas fell slightly over the past year as production had been much greater than the gross additions. The Canadian Petroleum Association (CPA) had estimated that while gas production rose by 4 per cent, the volume of new discoveries and existing reserve revisions declined by almost 80 per cent compared to the previous year. Although drilling for natural gas has remained somewhat stable during the past few years in all regions, reserves from new discoveries in the producing and frontier areas have been greatly reduced. At the start of 1986, the natural gas reserves stood at 2.8 trillion m^3, with 75 per cent (2.1 trillion m^3) being located in the producing regions. Remaining established reserves of marketable natural gas in producing regions at the end of 1984 were 2.1 trillion m^3 and about 0.5 trillion m^3 are carried for the frontier areas.

PRODUCTION

The production of conventional crude oil and synthetic crude oil (Suncor and Syncrude plants) is expected to average some 231 000 m^3/d during the year, a decline of 3 000 m^3/d compared to 1985. While conventional production fell, synthetic production rose due to minimal production and maintenance downtime. Alberta's conventional output has continued to slip since 1984, now down by 6 per cent to 159 000 m^3/d of light/medium and heavy oils, whereas it was at 169 000 m^3/d previously. During the past couple of years, Canada's bright spot has been the Norman Wells field in the Northwest Territories. Imperial Oil Limited, the operator of Norman Wells, has markedly increased its oil production to 4 150 m^3/d from 460 m^3/d in 1983, through development drilling, gas lift operations and water injection.

Natural gas liquids production is anticipated to drop by 9 per cent this year, to 51 000 m^3/d from 56 000 m^3/d in 1985. Each of its components (pentanes plus, propane, butane, and ethane) have recorded declines in output. Separate figures for NGL production show that ethane production statistics were first kept in 1977, at which time some 1 000 m^3/d were produced. Now, nine years later, its share of total output is almost 25 per cent, an indication of its importance as a natural gas by-product.

While sales of Canadian natural gas to its domestic market has remained unchanged over the previous year, exports to the United States have fallen by 15 per cent, from 72 to 61 million m^3/d. Current total throughput has been reduced by 6 per cent, to 196 million m^3/d from 1985's record level of 209 million m^3/d.

RESOURCES

The Geological Survey of Canada assesses by a probabilistic method the petroleum basins throughout the country to estimate the undiscovered oil and gas resources. A recent GSC report describes the light and medium gravity oil potential in the Western Sedimentary Basin. After studying 65 established exploration plays in this region, it is estimated that an additional 590 million m^3 of technically recoverable oil, dispersed in more than 4,000 individual pools, will be discovered at an average (50 per cent) expectation. On the average, future discoveries are expected to contain smaller reserves than those made in the past. According to the 1983 GSC report of Canada's total estimated petroleum resources, the oil potential ranges from 1 500 million m^3 to 9 000 m^3 and its expected value (50 per cent) is at 4 700 million m^3. The corresponding natural gas potential ranges from 4 300 billion m^3 to 18 000 billion m^3 with a 50 per cent expectation of 9 500 billion m^3.

HEAVY OILS - OIL SANDS

Canada's two commercial oil sands plants (Suncor Inc. and Syncrude Canada Ltd.) had a combined output, during the year, exceeding 28 000 m^3/d of synthetic crude oil from licenced reserves of 3 900 million m^3 in the Athabasca region of northeastern Alberta. The province estimates the presence of some 160 000 million m^3 of raw bitumen - heavy oil in its oil sands deposits, of which 55 000 million m^3 are ultimately recoverable under today's technology. The Suncor and Syncrude plants extract the bitumen through open-pit mining by large bucket wheels, transport the material to their processing plants via conveyor systems and then separate the heavy bitumen from the sand by a hot water process. The bitumen is processed to give lighter petroleum products, mainly: naphtha, kerosene and gas-oil. These products are then mixed together and called "synthetic crude oil" which is shipped by pipeline to refineries in southern markets.

Besides the open-pit mining operations, there are several in situ bitumen - heavy oil projects in western Canada that produce oil, and make a significant contribution to the country's crude output. In addition to the two major older operations (Esso Resources Canada Limited at Cold Lake and the British Petroleum Company p.l.c./Petro-Canada at Wolf Lake), a third facility operated by Shell Canada Limited has begun commercial production in Peace River. These three currently produce some 13 000 m^3/d and all have plans for future expansion. There are many other smaller projects in Saskatchewan and Alberta but in many cases activities have been slowed because of low oil prices.

Another source of crude oil is that which remains unrecovered in an existing pool after primary and secondary recovery has taken place. This residual oil can be recovered in part through enhanced oil recovery (EOR), by means of thermal and chemical processes. These "tertiary" methods are oil price-sensitive because of high capital and operating costs. The GSC estimates the potential in the western producing provinces to be from 160 to 950 million m^3.

OUTLOOK

The projected increase in industry activity for 1986, forecast in late 1985, did not materialize because of the rapid fall in crude oil prices. All of the industry's exploration indicators declined markedly, ranging from 30 to 80 per cent of the previous year's level. Industry restructuring through company acquisitions and mergers can be expected to improve profit margins in coming years.

An agreement between OPEC members this December proposes production cutbacks to balance demand and supply at oil prices of about $US 18 per barrel. Based on the current rate of exchange between Canada and the United States, this would translate into about $Cdn 25, which is believed enough to sustain moderate levels of exploration and development in western Canada and some frontier regions.

In June 1985 and November 1986, deregulation respectively of crude oil and natural gas pricing occurred in Canada. Market-based pricing, achieved by negotiation between producers and purchasers was established for domestic and exports supplies of oil and gas.

During the year, both levels of government found it necessary to assist the petroleum industry. The Alberta government introduced an exploration and development incentive program designed to inject $500 million into various types of drilling and geophysical programs. In addition to this, it also reduced oil and gas royalties, allowed for royalty holidays and extended the royalty tax credit program. The province is also expected to simplify its natural gas royalty system.

The federal government eliminated its Petroleum and Gas Revenue Tax (PGRT) some 27 months ahead of schedule. In addition to the termination of PGRT, the government changed the tax on royalty income, a measure that affected taxpayers who received income as a royalty on oil or gas production.

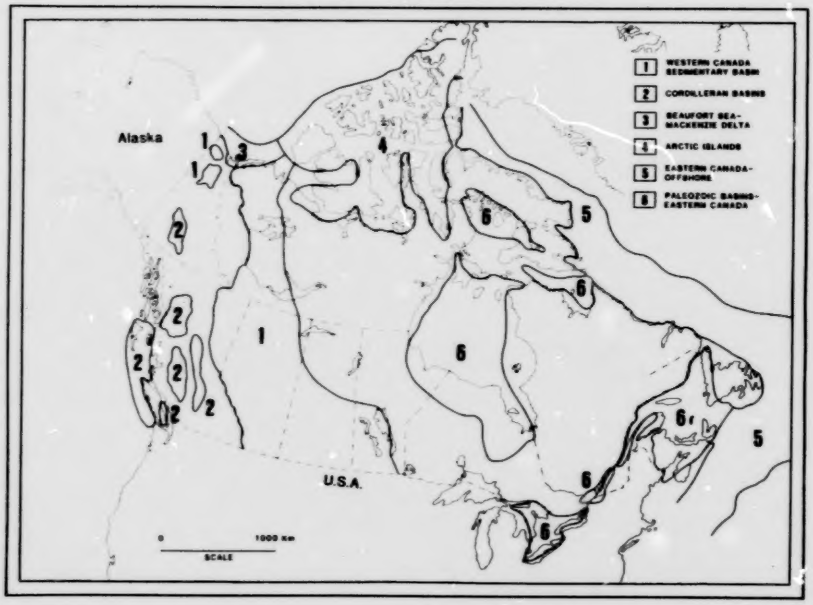
The Canadian Petroleum Association has recently predicted that drilling activity in 1987 will be reduced by 30 per cent (to 5,000 well completions) because of low prices and decreased cash flow. It also forecasts that investment will fall by 30 per cent to about $4 billion. Low oil prices have caused significant employment losses in the petroleum sector.

Canadian oil analysts and trade associations anticipate a recovery for the industry overall because of the deregulated environment and firming of oil prices. Diminished activity is expected in the first quarter of 1987, following the termination of 1986 provincial incentive programs, but the situation is expected to improve during the remainder of the year. The oil sands and heavy oils resources of Alberta and Saskatchewan will continue to attract investment for development as domestic needs for light oils and export opportunities for heavy oils grow. Frontier developments generally require stable, higher prices to proceed.

Conversion factors (approximate):

1 cubic metre (m^3) oil = 6.3 barrels
1 cubic metre (m^3) gas = 35.3 cubic feet

CANADA'S PETROLEUM REGIONS


1 WESTERN CANADA SEDIMENTARY BASIN
2 CORDILLERAN BASINS
3 BEAUFORT SEA-MACKENZIE DELTA
4 ARCTIC ISLANDS
5 EASTERN CANADA-OFFSHORE
6 PALEOZOIC BASINS-EASTERN CANADA
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SCALE
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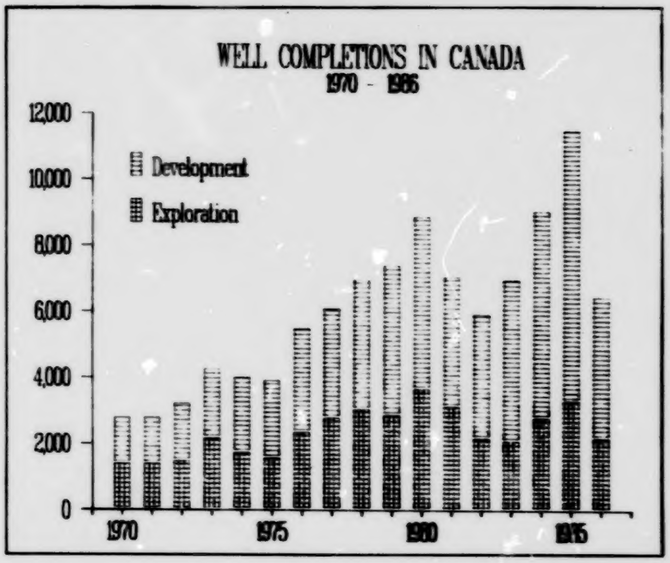
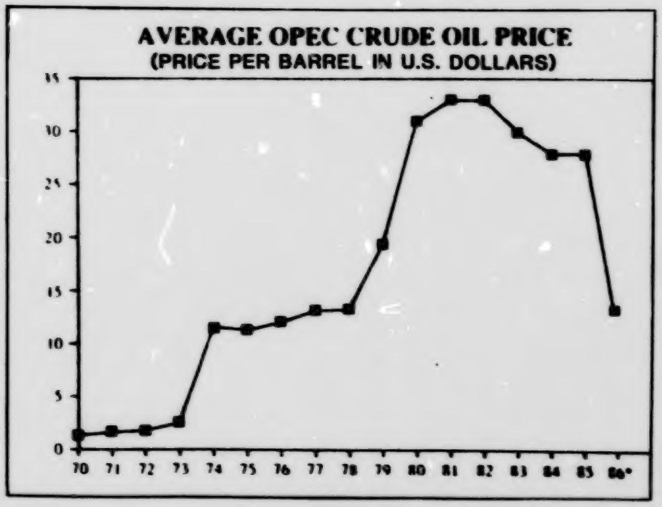


WELL COMPLETIONS IN CANADA
1970 - 1986



AVERAGE OPEC CRUDE OIL PRICE
(PRICE PER BARREL IN U.S. DOLLARS)

Diatomite

DANIEL J. SHAW

Diatomite is a siliceous, sedimentary rock composed mainly of opaline silica formed from the fossilized skeletal remains of the diatom, a unicellular aquatic plant related to the algae. Diatoms, of either fresh or salt water origin, extracted silica from the surrounding water and secreted it as a microporous, intricate, complex fossil arrangement, often symmetrical in design, which accumulated to form deposits, some of which are hundreds of feet thick. Diatomite's usefulness stems from its physical characteristics and chemical inertness. The porous structure provides unusual filtering properties, low bulk-density, large surface area and low thermal conductivity. The main requirements for the formation of a commercial scale deposit are: large shallow basins, an abundant supply of soluble silica, often provided by vulcanism; sufficient nutrients for the diatoms; the absence of growth inhibiting constituents such as a high concentration of soluble salts; and little deposition of clastic sedimentary materials. While many known occurrences appear across the world, large-scale production occurs primarily on the western coast of the United States and in western Europe.

CANADIAN INDUSTRY, DEVELOPMENTS AND TRADE

Diatomite has been produced every year in Canada since 1896; however, this production has fallen short of Canadian consumption every year and has been augmented by imports, primarily from the United States. Essentially all Canadian diatomite production was from lake deposits in Nova Scotia up until 1941; however, since 1955, all production has originated from the Quesnel area in central British Columbia.

In 1967, Dome Petroleum Limited acquired the mining rights of Crownite Diatoms Ltd. and through a name change formed the wholly-owned subsidiary - Crownite Industrial Minerals Ltd. - to mine and process diatomite and pozzolanic shales from deposits just west of Quesnel. Crownite Diatoms Ltd. had operated for about six years on a very limited basis, producing mainly burnt shale pozzolan which was used as a construction material. Under Crownite Industrial Minerals' ownership the plant had a rated capacity of 36 000 tpy and produced low-quality diatomite suitable for the manufacture of insulating brick for use in the refractories industry and as a carrier in the production of fertilizers.

In early-1982, the Crownite Industrial Minerals' plant changed ownership and was reopened in mid-December under the name of Microsil Industrial Minerals Ltd. Partnership, after upgrading to a more efficient unit. The new plant is concentrating on the production of granular 'aggregate' products such as floor absorbents, soil conditioners, granular chemical carriers, pet litters, plus a limited number of processed powder products.

For confidentiality reasons, statistics on Canadian production and exports are not available for publication. However, Canadian imports of diatomaceous earth was 24 227 t in 1985, up 1.4 per cent from 1984. The sources of these imports were the United States and Denmark.

MARKETS, SUBSTITUTES AND WORLD TRADE

Diatomite is marketed in three grades - natural, calcined or pink, and flux-calcined or white. Although mining is by open-pit methods and normally uncomplicated, present processing techniques are not simple. For example, common size reduction methods such as ball milling or grinding would destroy the delicate structure of the mineral which would render it useless for such applications as filtration and as a flatting agent in paint. Current production techniques require costly plant equipment such as dryers, kilns, cyclones and air classifiers to produce a product of high purity and consistent uniformity.

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The principal use for diatomite is as an industrial filtration medium. The porous structure of the individual diatoms and of their arrangement within the bedded deposit results in a material with about 90 per cent voids, capable of removing solid particles as small as 0.1 micron in size, while not impeding the flow of liquid through the filter. Flux-calcined grades which are calcined at up to 2200°F with alkali salts, although more expensive, are favoured as filtration aids.

Diatomite is one of the principal extender minerals or fillers. It is used as a flatting agent in paint, a bulking agent in paper, a pozzolanic agent in concrete and a shrinkage-control agent in plastics. These applications usually require calcined material which would average over 90 per cent silica content and have a near-white appearance.

As a powder, an aggregate or in the form of bricks, blocks or slabs, diatomite is used as an insulation material, its cellular structure providing sound proofing qualities and low thermal conductivity. In natural form (uncalcined) diatomite in the minus 325-mesh size range is used as a fertilizer coating and insecticide carrier.

The successful marketing of diatomite products by major producers has depended, to a large degree, on their ability to furnish high-calibre technical sales service, backed by strong research and development facilities, to the specialized needs of customers. While these expensive facilities have been an effective barrier to entry into the field, the existence of small producers supplying local or lower grade markets attests to their ability to compete successfully against their large counterparts. The large diatomite producers are well established and market their products under trade names, one or more of which the customer recognizes as best serving its requirements.

Diatomite has many substitute materials; however, in most instances the mineral's unique properties and characteristics make it the ingredient of choice. For filtration applications, such as pharmaceuticals and sugar processing, expanded perlite, asbestos and silica are making inroads. Mica, clay and ground talc are successfully replacing diatomite as a flatting agent in paint and as a filler material in paper. The consequences of such substitution is not as injurious for certain diatomite producers, as they are diversified into the production of perlite and talc.

United States: In 1985, a breakdown of U.S. diatomite production sold, including exports, reveals that the filtration use accounts for the largest share of demand with 67 per cent. Over the last decade, filtration's market share of demand has been relatively stable, between 60 to 68 per cent of U.S. shipments. Filler applications accounted for the second largest share of demand in 1985 with 22 per cent of U.S. shipments; while additive aplications, insulation, abrasives and absorbents accounted for the remaining 11 per cent of demand.

Current world diatomite production is estimated at 1.5 million t. In 1985, the United States was by far the largest producer, accounting for approximately 38 per cent of world production. U.S. production, 578 000 t in 1985, is confined to four western states - California, Nevada, Oregon and Washington. Of these, diatomite operations in California account for more than half of U.S. production. Four companies - Eagle-Picher Industries, Inc., Grefco, Inc., Manville Products Corporation, and Witco Chemical Corporation account for a large proportion of diatomite extracted and processed in the United States.

Europe: The most important European producers are located in France and Denmark, where 1985 production is estimated at 218 000 t and 132 000 t respectively. Over 90 per cent of French production comes from the operations of Carbonisation et Charbons Actifs SA in Cantal and Ardèche. The other French producer is Diatomeé et Dérivées, SA operated by the Manville Corporation subsidiary, Manville International Corporation. Manville International Corporation is also involved in diatomite mining and processing in Spain, Iceland and Mexico, and when combined with Manville Products Corporation's production in California represents 25 per cent of world production. The U.S.S.R. and Romania are also important producers; however, details from these countries are unavailable. Together, these two countries are estimated to produce 281 000 t of diatomite - representing about 18.5 per cent of world production.

OUTLOOK

The outlook for diatomite is one of continued steady growth both in the short and long term. As concern for the environment and health becomes more apparent, especially in developing countries, the need for more efficient filtration of water supplies and industrial and chemical wastes, for example, will become greater. From the 1985 base, demand for diatomite is expected to increase at an average annual rate of about 4 per cent through 1990. The main increases will be in filtration applications where diatomite's performance is unmatched.

TABLE 1. CANADA, DIATOMITE IMPORTS, 1981-86, AND CONSUMPTION, 1982-85

	1981		1982		1983		1984		1985		1986[1]	
	tonnes	$000	tonnes	$000	tonnes	$000	tonnes	$000	tonnes	$000	tonnes	$000
Imports												
Diatomaceous earth												
United States	25 382	5,311	23 130	5,074	23 298	5,382	23 892	6,339	24 223	5,982	19 938	4,918
United Kingdom	163	58	-	-	-	-	-	-	-	-	-	-
Denmark	-	-	-	-	-	-	-	-	4	2	-	-
Total	25 545	5,369	23 130	5,074	23 298	5,382	23 892	6,339	24 227	5,984	19 938	4,918

	1982	1983	1984	1985P
	(tonnes)			
Consumption				
Fertilizers, stock and poultry feed	7 972	9 118	8 136	8 921
Refractrory brick, mixes	555	1 686	2 658	3 162
Sugar processing	1 487	2 179r	2 251	3 523
Other	4 004	3 206	2 324	3 155
Total	14 018	16 189r	15 369	18 761

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] First nine months of 1986 only.

P Preliminary; r Revised; - Nil.

TABLE 2. WORLD DIATOMITE PRODUCTION FOR 1970, 1975, 1980 AND 1982-85

	1970	1975	1980	1982	1983	1984	1985
				(000 tonnes)			
United States	542	514	625	556	562	569	578
Brazil	-	-	17	16	16	16	18
Denmark	238	236	152	125	125	130	132
France	160	209	218	200	240	218	218
West Germany	92	45	53	42	43	44	45
Iceland	13	23	18	20	25	25	27
Spain	18	23	27	20	65	54	54
Other Western World Countries	156	177	155	132	171	173	171
Centrally Planned Countries	372	408	227	277	277	281	281
World total	1 591	1 635	1 492	1 388	1 524	1 510	1 524

Source: Mineral Commodity Summaries, U.S.B.M.
- Nil.

Ferrous Scrap

R. M^c^INNIS

In 1986, the Canadian ferrous scrap industry faced a market very similar to that of the previous year. Volumes sold and prices received were very close to those of 1985.

The market was flat in 1986 with little change in monthly volumes or prices. By the end of July, prices had increased marginally and remained relatively steady during the last quarter of the year. Canadian market for scrap was quite different from that of the United States where prices for No. 1 heavy melting scrap dropped from about $US 78 a short ton in January 1985 to approximately $US 63 in December.

The declining value of both the Canadian and American dollar helped to produce a slight increase in exports of ferrous scrap. Sales to developing Asian countries were very good.

In recent years, scrap purchases have followed closely the volume of steel produced in a given month as many steel mills have kept inventories of scrap to a minimum. A just-in-time scheduling of delivery of materials sourcing has become a common operating procedure in the industry.

There was little change in the volume of scrap purchased by the Canadian steel industry in 1986. The steel mills purchased 30.2 million t in the first 10 months of 1986, compared with 29.6 million t in the same period of 1985. The total consumption of scrap by the steel industry including own-generated scrap was 6.75 million t in 1986. Ferrous scrap consumed by the steel industry in 1985 totalled 7.04 million t.

A considerable increase in the amount of continuously cast steel will occur as new casting equipment comes on-stream. Stelco Inc., Dofasco Inc., IPSCO Inc. and Atlas Steels, division of Rio Algom Limited are all installing new continuous-casting equipment, which will reduce the amount of own-generated scrap produced in these mills. Since the amount of scrap used in the production of a tonne of steel is unlikely to diminish, Canadian steel companies can be expected to use larger tonnages of purchased scrap.

The demand by scrap users for higher quality products, especially in terms of the chemical analysis, will continue as the world steel industry pursues its quest for better steels. Price changes are indicated by the Ferrous Materials Price Index D614305, published by Statistics Canada. For 1984 the index average was 104.2, in 1985 the average was 100.7 and in October 1986, it was 99.9. The index 100 applies to the base year, 1981.

CANADIAN INDUSTRY STRUCTURE

The Canadian ferrous scrap industry comprises approximately 600 firms. These companies collect, store and process the ferrous scrap for sale to the user industries. Most of these firms are small and are involved only in the collection of scrap. Dealers who are also involved in the sorting and storage of scrap are fewer in number, while those who engage in capital intensive processing comprise the smallest group. Scrap processing requires heavy equipment such as mechanical shredders, shears, presses and bundlers. This segment of the scrap industry produces the products needed by the user industries, such as steel mills. A new competitively sized processor would have to spend in excess of $10 million on capital equipment today.

Scrap is such an important raw material that it is common practice for Canadian steel producers to hold equity in scrap processing companies in order to reduce the risk of supply problems, and to assure quality control of the scrap to meet their needs.

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Autobody shredding equipment represents a significant capital investment in the scrap industry. There are presently 15 shredders installed in Canada, which in aggregate have the capacity to process about 1.3 million cars per year.

Statistical Process Control was implemented at most of the large processes in response to market demand for higher levels of quality control of purchased scrap.

Capital expenditures in 1986 were low, the major one being $5 million for installation of a shredder at Co-Steel Inc.'s plant in Whitby, Ontario.

CANADIAN DEVELOPMENTS

Prices and shipments of scrap increased during 1984, and then stabilized in 1985 and 1986.

In an integrated steel mill the ratio of purchased to own-generated scrap, that is consumed by the mill, varies from year to year. This ratio for the Canadian steel industry was 0.93 in 1984 and 1.02 in 1985, and .90 in 1986. The ratio is partly a function of the price of scrap and partly dependent on other factors. For example, in times of low steel demand, steel mills may use iron produced in their operating blast furnaces in place of purchased scrap to avoid banking the blast furnaces. This measure can also maintain iron ore and coal consumption near contracted levels. This practice may have been applied in 1982 when the amount of purchased scrap used per tonne of steel produced was unusually low, even though the price of scrap was especially depressed. Greatly expanded use of continuous casting equipment will influence this ratio in the next few years.

In the case of the electric furnace steel industry, the price-demand relationship is much more direct because ferrous scrap is the principal raw material. Electric furnace mills can consequently produce steel at considerably less cost than integrated mills in periods of low steel demand and low scrap prices, allowing them to capture market share and remain profitable. Many companies in this industry are installing ladle refining facilities to improve the quality of their products thereby allowing them to compete with the integrated mills over a larger product range.

The increasing use of continuous casting and improvements in basic oxygen furnaces (BOF) such as the advent of Lance Bubbling Equilibrium (LBE) equipment, will tend to reduce the levels of own-generated scrap and increase the demand for purchased scrap. Also, the entrance of QIT-Fer et Titane Inc. into the production of steel in 1986 will probably add to the demand for purchased scrap. QIT currently produces pig iron as a co-product with titanium dioxide in its electric furnace smelting facilities at Tracy, Quebec.

The QIT steelmaking facility will be a potential scrap customer because, with its capacity to produce 440 000 tpy of steel billet, it could use up to 132 000 tpy of scrap, although the present intention is to make high quality billet using only its own pig iron.

Canada is more than self-sufficient in scrap, but there are regional differences in supply and consumption that result in significant trade between Canada and the United States. A high percentage of scrap that is in excess of eastern Canadian needs is exported to markets in the northeastern United States while the western Canadian market, which is generally deficient in local scrap, imports it from the American northwest and central regions.

The ferrous recycling industries in Canada and the United States share what they consider to be a single market. There are few restraints to the movement of scrap across the border and, consequently, prices in the United States have a major impact on those in Canada. During the last three years, 90 per cent of Canadian scrap exports have gone to the United States. Exports helped support the domestic price, especially in the last half of 1986. Virtually all Canadian imports originate in the United States.

As the recycling industry in Canada has grown, and as it has become more mechanized and efficient, more scrap has been available for export. The international market for scrap is very competitive and tends to fluctuate widely from year to year. Countries which have a history of buying significant volumes of scrap include South Korea, Spain, Italy and Japan.

SCRAP CLASSIFICATION

The producers of ferrous scrap describe unprocessed scrap by its origin. Home or own-generated scrap is produced in the manufacture of steel mill products, whereas prompt industrial scrap is generated by the secondary manufacturing industry and obsolete scrap comes from discarded machinery, equipment and structures.

Prompt and obsolete scrap is generally processed by the recycling industry and is made into a number of products for which standards have been written by the Canadian Association of Recycling Industries.

Scrap classification is based on factors such as size, type of material, cleanliness, and residual alloys. The most common grades are as follows:

Scrap Products

Class No.	Grade and Type
100	No. 1 Heavy Melting Steel
101	No. 1 Hydraulic Bundles
102	No. 2 Bushelling - Prepared
103	No. 2 Heavy Melting Steel
104	Plate and Structural Steel
105	No. 2 Hydraulic Bundles
106	Hydraulic Silicon Bundles
107	No. 2 Bushelling - Prepared
108	No. 1 Bushelling (Clips)
109	Short Shovelling Steel Turnings (Crushed)
110	Machine Shop Turnings
111	Mixed Turnings and Borings
112	Cast Iron Borings
113	No. 1 Shredded Scrap
114	No. 2 Shredded Scrap
115	Briquetted Steel Turnings - Alloy Free
116	Briquetted Steel Turnings - Alloyed
117	Foundry Steel

USES

Most ferrous scrap is used in electric furnace steel mills and integrated mills for the production of steel. The foundry industry is the second largest market for scrap. Minor markets include the production of iron powders, sinter, ferroalloys and abrasives.

Scrap used in the electric furnace steel industry must be carefully selected in order to minimize the melting time and the consequent cost of energy per tonne, and to maximize the furnace productivity. Depending on the grade of scrap, it can take from 1 100 to 1 200 kg of scrap to produce 1 000 kg of steel. Tramp elements in scrap are a larger problem in electric furnaces than in integrated mills because there is less opportunity to remove them by oxidation and slagging or to dilute them in the melt by addition of pig iron. Certain elements like tin are more difficult to remove than others. Thus scrap grades low in tramp elements are preferred by electric furnace mills.

Open-hearth and basic oxygen furnaces (BOF) provide more scope for steel refining. In these, scrap can be added at about 50 per cent and 30 per cent of the respective charges. In a BOF a small amount of scrap is necessary to absorb the energy released when the carbon in the molten iron is removed by oxidation. This same energy can be used to melt up to 30 per cent scrap. Apart from the saving in energy, ferrous scrap is usually much cheaper than iron produced in a blast furnace. Therefore, integrated mills focus some of their research effort on optimizing the amount of scrap charged to their steel furnaces. These types of furnaces can tolerate relatively higher levels of impurities or tramp elements because of the diluting effect of the main charge of pig iron as well as the greater potential for the removal of unwanted elements.

On balance, integrated steel operations have more flexibility than electric furnaces with respect to the percentage of scrap in furnace feed and they are also less dependent on scrap availability and price. In periods of high demand, when integrated mills operate near capacity, scrap usage is often maximized to increase steel production even if scrap prices are high. The reverse situation may apply when steel demand is low and scrap use is governed by a minimum blast furnace operating rate. In this case it would be necessary to restrict scrap use to avoid over-production even if scrap were available at a very low price.

OUTLOOK

Both integrated and electric furnace mills are experiencing rapid technological change which will have a long-term impact on the scrap market.

Recent research and development efforts have focused on increasing the amount of scrap that can be used in the oxygen steel converter. New developments include systems in which fuel and oxygen are blown into the converter to preheat the scrap charge, and Lance Bubbling Equilibrium (LBE) equipment in which inert gases are blown through the bottom of a BOF-type vessel. The more efficient mixing created by the LBE system results in higher yields, increases the amount of scrap that can be charged, and improves the quality of the steel produced. LBE equipment is being installed in a number of Canadian BOF's.

The market for scrap and the amount of scrap purchased by integrated mills also vary with the amount of scrap produced within the steel plant. The introduction of continuous casting has considerably reduced the ratio of home to purchased scrap. Yields from molten crude steel to finished steel can increase by almost 20 per cent when continuous casting is used instead of ingot casting. At least four new continuous casters will be installed in Canadian mills in the next few years.

In the case of electric furnace mills the main substitute for scrap is direct reduced iron (DRI), which, when melted with scrap, has the advantage of diluting the concentration of tramp elements. However, DRI is considerably more costly than scrap.

Technical developments in this industry have centred on the treatment of the steel in a holding vessel, a process called Ladle Metallurgy. This technique frees the furnace for more production and allows a final treatment to improve the chemistry of the steel produced. The improved products will allow electric furnace mills to capture a greater share of the steel market and thereby increase the demand for scrap.

Scrap usage is expected to increase by approximately 3 per cent in 1987. In the medium-term to 1990, usage should increase 4 to 5 per cent per year as more continuous casting equipment is added and a greater percentage of the steel made in North America is produced in electric furnaces. The growth rate after 1990 is forecasted to slow to approximately 2 per cent per year.

The anticipated rising demand for higher quality scrap, especially in terms of low levels of tramp elements and more desirable product forms, will likely require the installation of more sophisticated process equipment. This could include x-ray spectrometers to analyze scrap, mechanical separators, high pressure bailers and briquetting machines for the production of high density product, and better shredders that would improve the separation of separating ferrous metal from nonferrous and nonmetallic components.

PRICES

The composite price, in U.S. dollars per long ton delivered, for No. 1 heavy melting steel scrap, as quoted by the American Metal Market, decreased from $80.00 in January 1985 to $71.50 in December 1985. Prices increased in 1986 with the highest price of $76.20 in August 1986. The price was flat for the last quarter and was $75.80 at the end of 1986.

The price index for ferrous scrap (1971 = 100) published by Statistics Canada Catalogue 62-001 was changed from the base year 1971 to 1981 and the number of classes of scrap reduced to a single composite "Iron & Steel Scrap".

TABLE 1. CANADA, IMPORTS OF STEEL SCRAP, BY PROVINCE OF ENTRY, 1984-86

		1984		1985		1986P	
		World	U.S.	World	U.S.	World	U.S.
Nova Scotia	tonnes	-	-	-	-	38	38
	$000	-	-	-	-	9.7	9.7
New Brunswick	tonnes	5	5	109	109	65	65
	$000	374	374	19	19	6.8	6.8
Quebec	tonnes	28 216	28 199	27 548	27 368	31 770	31 757
	$000	5,846	5,843	2,897	2,727	3,521	3,519
Ontario	tonnes	430 038	429 980	402 019	402 015	274 054	273 988
	$000	41,697	41,673	38,691	38,691	28,458	28,374
Manitoba	tonnes	44 998	44 998	41 886	41 886	21 568	21 568
	$000	4,135	4,135	3,420	3,420	1,420	1,420
Saskatchewan	tonnes	185 759	185 759	83 785	83 785	42 006	42 006
	$000	15,798	15,798	6,888	6,888	3,620	3,620
Alberta	tonnes	40 868	40 868	19 919	19 919	19 939	1 875
	$000	4,212	4,210	1,830	1,830	19 939	1,875
British Columbia	tonnes	2 186	2 186	2 413	2 413	5 369	5 369
	$000	995	495	265	265	446	446
Total	tonnes	732 084	731 996	577 678	577 499	394 809	394 731
	$000	72,684	72,655	54,010	53,841	39,356	39,270

Source: Statistics Canada.
P Preliminary; - Nil.

TABLE 2. CANADA, EXPORTS OF STEEL SCRAP, BY PROVINCE OF LADING, 1984-86

		1984		1985		1986P	
		World	U.S.	World	U.S.	World	U.S.
Newfoundland	tonnes	-	-	3 827	-	-	-
	$000	-	-	553	-	-	-
Nova Scotia	tonnes	-	-	32 695	8 147	1 575	1 563
	$000	-	-	4,112	1,222	247	244
Prince Edward Island	tonnes	-	-	-	-	104	104
	$000	-	-	-	-	15	15
New Brunswick	tonnes	221	171	2 811	2 811	10 669	2 883
	$000	49	46	388	388	1,472	361
Quebec	tonnes	199 055	15 914	245 469	17 491	176 250	25 922
	$000	20,121	2,029	29,778	2,068	15,132	3,239
Ontario	tonnes	376 182	348 002	414 688	373 167	521 554	466 004
	$000	34,288	30,994	38,149	32,421	49,025	42,984
Manitoba	tonnes	1 171	1 171	991	991	5 248	5 248
	$000	205	205	93	93	813	813
Saskatchewan	tonnes	-	-	-	-	86	26
	$000	-	-	-	-	86	26
Alberta	tonnes	832	832	583	170	299	168
	$000	90	90	193	24	100	63
British Columbia	tonnes	140 012	139 657	108 746	101 795	8 133	77 259
	$000	14,485	14,399	10,886	9,842	10,886	93,792
Yukon	tonnes	-	-	230	230	1 429	127
	$000	-	-	41	41	143	7
Total	tonnes	717 455	505 746	810 040	504 802	811 007	579 279
	$000	69,237	47,763	84,193	46,100	77,860	55,864

Source: Statistics Canada.
P Preliminary; - Nil.

TABLE 3. CANADA, EXPORTS OF STAINLESS STEEL SCRAP, BY PROVINCE OF LADING, 1984-86

		1984		1985		1986P	
		World	U.S.	World	U.S.	World	U.S.
Newfoundland	tonnes	-	-	-	-	-	-
	$000	-	-	-	-	-	-
Nova Scotia	tonnes	100	20	74	-	211	-
	$000	80	13	67	-	236	-
New Brunswick	tonnes	332	23	120	-	215	27
	$000	337	23	105	-	167	79
Quebec	tonnes	3 221	767	4 301	1 507	3 601	2 004
	$000	2,986	710	3,725	1,294	2,769	1,302
Ontario	tonnes	17 364	6 240	21 850	16 775	20 594	7 103
	$000	15,914	4,208	94,973	6,479	17,456	4,948
Manitoba	tonnes	182	166	352	205	225	169
	$000	100	87	263	130	225	169
Saskatchewan	tonnes	-	-	-	-	4	8
	$000	-	-	-	-	4	8
Alberta	tonnes	46	46	2	-	140	163
	$000	28	28	60	-	146	171
British Columbia	tonnes	1 548	591	1 520	368	477	287
	$000	1,068	233	1,194	143	2,159	1,583
Total	tonnes	22 793	7 854	28 218	11 577	27 104	10 026
	$000	20,433	5,302	22,190	8,046	22,534	6,934

Source: Statistics Canada.
P Preliminary; - Nil.

TABLE 4. CANADIAN CONSUMPTION OF IRON AND STEEL SCRAP

	1976	1977	1978	1979	1980	1981	1982	1983	1984r	1985r	1986p
						(000 tonnes)					
Used in steel furnaces	5 658	5 708	7 076	7 250	7 501	6 845	5 492[2]	6 449	7 383	7 039	6 950
Used in iron foundries	550	524	518	604	470	500	448	416	500	500	..
Other[1]	824	938	865	868	770	926	837	475	500	550	..
Total	7 032	7 170	8 459	8 722	8 741	8 271	6 777	7 337	8 400	8 000	6 950

Sources: 1982 Annual Census of Manufactures. 1983 and 1984 Catalogue 41-001 Primary Iron and Steel.

[1] Includes mainly steel pipe mills, motor vehicle parts, and railway rolling stock industries. [2] The number from Catalogue 41-001 was 4 619 or within 2.3 per cent.

p Preliminary; r Revised; .. Not available.

TABLE 5. AUTOMOBILE SHREDDERS IN CANADA

Company	Location	Capacity (tonnes/month)
Intermetco Limited	Hamilton, Ontario	8 000
United Steel and Metal, division of USACO Limited	Hamilton, Ontario	5 000
Bakermet Inc.	Ottawa, Ontario	8 000
Industrial Metal, a division of Co-Steel Inc.	Toronto, Ontario	10 000
Zalev Brothers Limited	Windsor, Ontario	8 000
Sidbec-Feruni inc.	Contrecoeur, Quebec	8 300
Fers et Métaux Recyclés Ltée	Longueuil, Quebec	4 000
	Laprairie, Quebec	4 000
Associated Steel Industries Ltd.	Montreal, Quebec	8 000
Native Auto Shredders	Regina, Saskatchewan	6 000
Cyclomet	Moncton, New Brunswick	4 000
Navajo Metals, division of General Scrap and Shredder Ltd.	Calgary, Alberta	3 000
Stelco Inc.	Edmonton, Alberta	8 000
Richmond Steel Recycling Limited	Richmond, British Columbia	5 800
General Scrap & Car Shredder Ltd.	Winnipeg, Manitoba	3 000
Total		85 100

Gallium and Germanium

M. GAUVIN AND J. BIGAUSKAS

The minor metals gallium and germanium generally have been recovered as by-products from bauxite (most gallium) and zinc, lead and copper ores (most germanium). Coal is also known to contain small quantities of germanium while iron ore may contain some gallium. The U.S.S.R. is believed to recover the metal from flue dusts produced by coal-burning plants. The opening of a gallium/germanium operation in the United States in 1986 represents the first mine facility which produces these elements as its major products. Some gallium is recovered from scrap, but germanium is recycled widely as new electronic scrap. Zone refining techniques for high-purity metals were originally developed for purification of germanium metal but now are used for many specialized metals including gallium. Electronic and optical-electronic uses account for over 90 per cent of the consumption of these metals or their compounds.

Gallium - a liquid metal at room temperature - can be combined with phosphorus, antimony or arsenic to form compounds with semi-conductor properties. Germanium is commercially available in tetrachloride, oxide, zone-refined (intrinsic) ingot, single crystal, doped semi-conductor and optic blank forms.

World gallium consumption is variously estimated at 40-60 tpy whereas germanium consumption is likely under 80 tpy. World primary production of gallium is estimated by the U.S. Bureau of Mines at about 30 tpy whereas total refinery production of germanium is about 80 tpy. Recycling of electronic and other scrap is particularly important to the germanium industry.

CANADIAN DEVELOPMENTS

Cominco Ltd. recovers germanium as a by-product from its Trail, British Columbia zinc smelter and refines both germanium and gallium to high-purity levels at its electronic materials operation at Trail, British Columbia. Cominco also has the potential to recover by-product gallium at Trail but presently acquires gallium raw materials from outside sources. Cominco also fabricates germanium and gallium arsenide semi-conducting materials at Trail, British Columbia.

Alcan Aluminium Limited operates high-purity gallium refining operations in Kingston, Ontario and Rorschach, Switzerland. The latter plant was purchased in 1985. The company announced plans to begin reclamation of gallium from scrap at Kingston in February 1987. Alcan also announced plans to build a new plant to extract gallium at its alumina-aluminum smelting complex in Jonquière, Quebec, by the end of 1987. Epitaxial gallium-arsenide wafers are produced in Phoenix, Arizona.

Some gallium is contained in feldspars at the Thor Lake, Northwest Territories beryllium-yttrium-rare earth deposit of Highwood Resources Ltd. and Hecla Mining Company of Canada Ltd. In September, the two companies formed a joint venture and agreed to undertake a feasibility study for the development of the beryllium and yttrium resources of the property.

Minor amounts of gallium are also found in mica minerals at Tantalum Mining Corporation of Canada Limited's (TANCO) Bernic Lake, Manitoba lithium-tantalum-rare metal deposit. TANCO produced tantalite ore from 1969 to 1982. The operation was closed due to the poor market for tantalite. The concentrator was modified in 1984, and production of ceramic-grade spodumene, a lithium mineral, began. Gallium, which replaces aluminum in certain micas, is not currently being recovered.

Germanium is also present in a number of zinc ores in Canada at levels averaging from 150 ppm to 250 ppm.

WORLD DEVELOPMENTS

Musto Explorations Limited, Vancouver, through its 100 per cent-owned St. George Mining Corporation in Utah, recovers gallium

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metal and germanium dioxide, as well as copper, silver and zinc in various products from secondary ores associated with a former copper mine - the Apex mine at St. George, Utah. Gallium capacity is 10 tpy and germanium capacity is 17.9 tpy contained in germanium dioxide. First deliveries of high purity gallium metal and germanium dioxide were made in April and August 1986, respectively. Metallurgical development work continued throughout 1986.

Production of gallium at other U.S. plants is relatively small. Annual domestic consumption on the other hand is estimated at 12 to 13 t. Thus, most demand has been met by imports from Switzerland, the Federal Republic of Germany and France. The germanium industry is larger and consists of four germanium refineries and, including the Utah operation, two extraction plants. Refinery production has been about 20 tpy in recent years according to the U.S. Bureau of Mines. Annual consumption is estimated at about 35 t. Imports from Belgium, the United Kingdom, France and West Germany provide a large part of U.S. demand.

In western Europe, major producers of refined gallium are Switzerland, West Germany and France. Germanium is produced in various forms by Austria, Belgium, France, the United Kingdom and West Germany. Estimated European consumption of gallium is 2 to 3 tpy. Germanium consumption is probably less than 30 tpy.

Bleiberger Bergwerks Union AG of Austria produces about 5 tpy of germanium in a fume-derived cake at its Gaillitz, Arnoldstein zinc and lead metallurgical works. The cake is exported for further processing.

Metallurgie Hoboken-Overpelt SA produces germanium metal in Belgium (annual capacity 64 t) from zinc plant residues and scrap. High-purity germanium production at the company's Olen works will increase with an expansion which is under way.

Rhône-Poulenc SA in France is a major producer of gallium with a capacity of some 20 tpy. The company announced that it will build, among other projects, a wholly-owned gallium extraction plant at Pinjarra, Western Australia to extract gallium from alumina refinery liquors from Alcoa of Australia Ltd. The gallium extraction facility will be operational in 1988 and is expected by the company to double world output of the metal. The company also announced in late-1986 that it would open a new gallium refinery at Freeport, Texas. Capacity is expected to be greater than current world consumption.

Société minière et métallurgique de Peñarroya S.A. of France produces germanium dioxide and germanium metal from by-products at its refinery at Noyelles-Godault and from materials produced by a subsidiary zinc plant in Italy. Zinc concentrates from the Malines mine in France are known to contain elevated germanium levels. Some gallium metal is also produced.

In West Germany, Ingal International Gallium GmbH produces gallium metal and oxide (annual capacity, 12 t) as well as gallium compounds. Ingal is owned equally by Billiton B.V. and Vereinigte Aluminium-Werke AG (VAW) of West Germany. The company is expanding its Schwandorf, West Germany, gallium refinery by 50 per cent. The first phase will be completed in early-1987. Feasibility studies also are under way for a new gallium extraction plant to replace the existing plant at Lünen by late-1988. The VAW alumina refinery which supplies Bayer liquor - the feed stock - will be closed at that time. Otavi Minen AG produces germanium dioxide and metal from copper refinery and zinc plant residues at its Neu-Isenburg, West Germany, rare metals plant. Preussag AG Metall produces or markets refined gallium and germanium from a variety of feeds including metallurgical by-products and gallium-bearing scrap at its Langelsheim, West Germany, plant.

In the United Kingdom, Mining and Chemical Products Ltd. (MCP) and its associated MCP Electronic Materials Ltd. extract and refine gallium metal and produce chemical compounds and semi-conductor compounds at Wembley, Middlesex and Workingham, Berkshire.

Elkem A/S in Norway announced plans to build a 5 tpy gallium extraction plant at Bremanger Smelteverke in Norway. The plant will cost Nkr 14 million and could begin production in early-1987.

Ziar Aluminum Works in Czechoslovakia and Hungarian Aluminum Corp. (Hungalu) in Hungary produce gallium metal from Hungarian bauxite ores in central Slovakia, Czechoslovakia and Ajka, Hungary, respectively. Ziar's output is believed to be about 3 tpy. Hungalu plans to double gallium metal output from its present 3.5 to 4 tpy by building a new $US 2.2 million cementation plant. The plant will replace the present mercury cathode (de la Breteque) electrolytic process. By 1988, Hungalu plans to produce 8 tpy of gallium metal from the 1.3 million t of bauxite it processes. Nearly all of this output is exported to markets in Japan, United States, United Kingdom, the Netherlands and France.

In Africa, La Générale des Carrières et des Mines du Zaire (Gécamines) produces copper-germanium concentrates at its Kipushi mine. Germanium is contained in the mineral renierite. The Tsumeb lead-copper-zinc-silver district in Namibia is known for the germanium content of its ores. Germanium there is contained in the minerals germanite and renierite.

Japanese consumption of gallium is estimated at 30 to 40 tpy while production is about 30 tpy. Consumption of germanium is estimated at under 7 tpy. Sumitomo Chemical Co. Ltd. is the largest producer of refined gallium metal. Raw materials are believed to come from associated alumina operations, from scrap and from imports. Dowa Mining Co., Ltd. produces gallium metal at its metallurgical operations in Akita prefecture. Dowa commissioned a new $US 3.2 million rare metal recovery plant in August 1986 to produce some 7 tpy of gallium from primary materials and 2 tpy from scrap reprocessing. Germanium also is produced. Mitsubishi Metal Corporation makes some 900 kg of gallium metal annually at its 1.2 tpy capacity plant at Ohmiya City, Saitama prefecture. Gallium arsenide (or gallium phosphide) semi-conducting compounds are also produced by Mitsubishi Metal Corporation, Sumitomo Electric Industries and a number of other companies in Japan.

The People's Republic of China was reported to have produced some 7 t of gallium in 1985. Japan and China agreed in early-1987 to cooperate in developing technology to extract gallium from iron ore. The project is expected to last for five years and will focus on deposits located in Sichuan province. Germanium is contained in certain lead-zinc deposits in China.

USES

Over 90 per cent of gallium consumption in the United States is in the form of gallium arsenide or gallium phosphide compounds for use in electronic semiconductors, light emitting diodes and lasers. Gallium-arsenide semi-conductors offer much faster performance than silicon-based ones, consume less power, and provide higher resistance to radiation in military and space applications. The major end uses for germanium in the United States are infrared optical systems (60 per cent), fiber optic systems (15 per cent), detectors (10 per cent) and semiconductors (5 per cent). Miscellaneous categories include catalysts, phosphors, metallurgy and chemotherapy.

STOCKS

The U.S. General Services Administration (GSA) has a stockpile goal of 30 t of germanium. The agency issued Basic Ordering Agreements in December 1986 as a first step in the purchasing process. The GSA expects to fulfill the goal within a year, depending on availability. It does not have a stockpile goal for gallium.

The Japanese government reaffirmed its intention to build and maintain a 60-day supply of rare and strategic metals by March 1988. The goal for the gallium stock is not known however.

PRICES

Prices for germanium and gallium vary greatly with the purity of material offered. In 1986 the list price for gallium remained at $US 525 per kg, unchanged from 1985. Germanium metal and dioxide prices were listed at $US 660 and $1,060 per kg, respectively, also unchanged from 1985. Significant discounting from all of these prices occurred during 1985 and 1986. For example, the price of electronic grade gallium ranged from about $US 500 to $US 600 in 1986. Penarroya changed the basis for germanium prices and now quotes an ECU price rather than a French franc price. On July 1, the germanium metal price was 975 ECU/kg f.o.b. Paris airport and the germanium oxide price was 500 ECU/kg.

OUTLOOK

Demand will depend on relatively new technological uses and developments. Estimates of the annual growth in world consumption are relatively high at 15-25 per cent for gallium and 7 per cent for germanium. Nevertheless, underutilized existing capacity and new plant capacity could likely meet much of this growth in the medium-term. The scale of plant developments in relation to market size suggests that price instability could be a continuing feature of both markets.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
CANADA					
35101-1	Metals, n.o.p., not including alloys in lumps, powders, ingots or blocks	free	4.1	25	free
35112-1	Gallium metal, gallium scrap, oxides of gallium, gallium arsenide, gallium phosphide, gallium arsenide phosphide and gallium aluminum arsenide, for the remelting, refining or recovery of the gallium content (expires June 30, 1987)	free	free	25	free
71100-1	All goods not enumerated in this schedule as subject to any other rate of duty, and not otherwise declared free of duty, and not being goods the importation whereof is by law prohibited	11.1	11.1	25	7

MFN Reductions under GATT (effective January 1 year given)	1986	1987
35101-1	4.1	4.0
71100-1	11.1	10.2

UNITED STATES (MFN)

		1986	1987
423.00	Gallium compounds	3.9	3.7
423.00	Germanium dioxide	3.9	3.7
628.25	Germanium, unwrought and waste and scrap	3.9	3.7
628.30	Germanium, wrought	5.9	5.5
632.24	Gallium metal, unwrought, and waste and scrap	3.9	3.7

Sources: The Customs Tariff, 1986, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated (1986), USITC Publication 1775; U.S. Federal Register Vol. 44, No. 241.

TABLE 1. GALLIUM, GERMANIUM AND GERMANIUM DIOXIDE U.S. PRODUCER PRICES, YEAR-END

	Gallium Metal[1]	Germanium Metal[1]	Germanium Dioxide[1]
		($US per kg)	
1977	550	315	178
1978	550	346	196
1979	510	522	307
1980	600	784	487
1981	630	923	575
1982	630	1,060	660
1983	525	1,060	660
1984	525	1,060	660
1985	525	1,060	660
1986	525	1,060	660

[1] Prices vary significantly with purity of material and pricing practices.

Gold

D. LAW-WEST

Gold prices recovered in 1986 following three consecutive years of decline. The 1986 average price was $US 368, up from $317 in 1985 and $360 in 1984.

Canadian gold production registered one of the largest increases in recent times: nearly 20 t above 1985 output of 87 t. Other countries such as the United States and Australia also showed large increases in production. In fact, the United States replaced Canada as the third largest gold producer in the world after South Africa and the U.S.S.R.

Gold prices are expected to remain in the $US 350-420 range for most of 1987. In the longer term there may be some downward pressure as more countries increase their production.

CANADIAN DEVELOPMENTS

Canada's production of primary gold increased substantially in 1986 to an estimated 104 654 kg, up from 87 560 kg produced in 1985. The largest increase occurred in Ontario where the three new gold producers at Hemlo operated for their first full year.

Gold production in Atlantic Canada increased during the year and should increase further in the near future. In New Brunswick, Gordex Minerals Limited started up the first commercial gold heap leaching operation in Canada. The company expects to recover at least 310 kg per year.

In Newfoundland, Hope Brook Gold Inc. decided to develop the province's first gold mine. Initial production will be an open-pit and heap leach operation starting by August 1987. Then, by late-1988, a 3 000 tpd underground mine and conventional mill should begin production with an annual gold output of nearly 4 000 kg. The project has an estimated life of eleven years and a total capital cost of $144 million. The project is being assisted by grants from both the federal and provincial governments totalling $24 million. The company expects employment during construction to be 400 and that at least 270 permanent jobs will be created.

Also in Newfoundland, Westfield Minerals Limited reported a significant discovery similar in occurrence to the Hope Brook deposit. Additional exploration work is required before economic viability can be determined.

Seabright Resources Inc. continued to achieve favourable results from the exploration program on its Beaver Dam property in Halifax county, Nova Scotia. Based on favourable deep diamond drill results, Seabright increased its capital spending by $20 million to total $30 million on the project. An independent firm has been hired to conduct a feasibility study for a 1 000 tpd production facility. The company is also carrying out exploration work on the nearby Forest Hill property.

In Quebec, Lac Minerals Ltd. encountered two new gold-mineralized zones at its Bousquet mine property near Val d'Or. While actual reserves have not been calculated, the zones are about 1.2 km east of the present shaft.

Société québécoise d'exploration minière (SOQUEM) formed a new company, Cambior inc., to operate SOQUEM's gold mining interests. They include a 50 per cent interest in the Doyon mine, as well as share interests in Aiguebelle Resources Inc. (24%), Sullivan Mines Inc. (31.5%) and Louvem Mining Company Inc., (34.8). Shares of Cambior were made available for public purchase in the Montreal Stock Exchange.

Lac Minerals Ltd. and its joint venture partner, Cambior inc. announced a program to expand the mill at the Doyon mine to 3 300 tpd from the present 1 650 tpd by late-1987. The $16 million expansion will

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allow all of the mine's ore production to be treated on-site instead of being shipped out for custom treatment. There is already a $40 million underground development program in progress that will see production shift from the open-pit that will be mined out in 1988.

Dumagami Mines Limited (owned 30 per cent by Agnico-Eagle Mines Limited) has decided to develop its gold property adjoining Lac Mineral's Bousquet mine. Production, scheduled for mid-1988, should begin at 2 000 tpd. The decision was based on the discovery of the new and higher grade west zone. The capital cost of the project is estimated at $31 million.

Early in the year, Falconbridge Limited sold its 56.7 per cent interest in Kiena Gold Mines Limited to Dome Mines, Limited for $86.6 million. The mine produces about 2 200 kg of gold annually at a cost of less than $US 200 per ounce.

The Casa Berardi region of northern Quebec continued as an area of major exploration activity in the province. Inco Limited (60 per cent) and Golden Knight Resources Inc. (40 per cent) completed a $7 million underground exploration program at their Golden Pond East property and began a production feasibility study. They are also discussing the construction of a road and an electrical transmission line to the property with the Government of Quebec. At year end, surface exploration had outlined a drill-indicated geological resource of 8 million t estimated to grade 7.2 g/t.

Teck Corporation and its joint venture partners, Golden Group Explorations Inc. and Golden Hope Resources Inc., outlined significant gold reserves following a 70 drill hole exploration program on their property in Estrades Township in the Casa Berardi region. The deposit also contains silver, copper, lead and zinc. The drilling program has indicated 2.6 million t of reserves grading 11.9 g/t gold equivalent.

The Hemlo gold field in northern Ontario provided for the largest increase in gold production in the country. The three new mines were in production throughout the year and were expected to produce a total of 16 740 kg of gold in 1986. Teck-Corona Operating Corporation experienced some ground control problems in the upper regions of the David Bell mine, and mill throughput was below its 1 100 tpd capacity. Production for the Golden Giant mine was higher than expected due to higher ore grades. Operations at the disputed Page-Williams mine continued without interruption during the year.

The legal dispute between International Corona Resources Ltd. and Lac Minerals Limited was unresolved at year-end. On March 7 the Ontario Supreme Court awarded the Page-Williams mine to Corona, accepting Corona's claim that Lac breached a trust to jointly develop the Williams property. The court also ordered Corona to pay Lac $154 million for the buildings and underground development. The decision was immediately appealed by Lac, which was allowed to continue operating the mine until the results of its appeal are known. The appeal was heard by the Ontario Court of Appeal for two weeks beginning November 17.

Campbell Red Lake Mines Limited and Amoco Canada Petroleum Company Ltd., partners in the Detour Lake joint venture, have indicated unofficial plans to proceed with underground development at the mine. The new underground mine should be producing at 1 800 tpd by December 1987. In the meantime, the mill is expected to continue operating from stockpiled ore.

American Barrick Resources Corporation has decided to develop the Holt-McDermott mine about 50 km north of Kirkland Lake. The company estimates that $50 million will be required to develop the mine to 430 m and to build a 1 500 tpd mill. Annual gold production of 3 110 kg is scheduled to begin by mid-1988.

Pamour Inc. completed a successful heap leach test on 10 000 t of low-grade waste from its No. 3 pit. Based on the test results, Pamour expects to recover about 160 kg of gold from 200 000 t of material next year.

ERG Resources Inc., a 65 per cent owned subsidiary of Pamour, has completed a feasibility study on recovering gold from the nearly 60 million t of tailings in the Timmins area. The tailings grade about 0.3 g/t and would be processed at a rate of 1 million t per month for eight months a year to recover 2 500 kg of gold. Pamour expects to spend about $65 million to bring the project on-stream by mid-1988.

Canamax Resources Inc. and Consolidated CSA Minerals Inc. expect to have a 350 tpd mill operating at their new Bell Creek mine by early-1987. Annual gold production should be about 700 kg. Total capital costs for the project are approximately $5.2 million.

Echo Bay Mines Ltd. has taken an interest in the Cameron Lake property of Nuinsco Resources Limited and is providing $3.6 million for the first phase of an underground exploration program which will include an 820 m ramp to a depth of 120 m. This phase is expected to be completed by August 1987 and, if successful in outlining significant ore reserves, a further $3.1 million may be spent in the next phase. Present estimates suggest reserves of 1.6 million t grading 5.0 g/t.

SherrGold Inc. continued with construction of its MacLellan mine near Lynn Lake in northern Manitoba. The company plans to spend $43 million to establish the mine and to refurbish the former Lynn Lake nickel-copper mill. The company has outlined 1.64 million t of mineable reserves grading 6.5 g/t, which is sufficient to support a 1 000 tpd milling operation for 5 to 6 years. There appears to be good potential for additional reserves in the immediate area.

Grãnges Exploration AB is awaiting a feasibility study and expects to make a final decision in early-1987 on its Puffy Lake property just north of Flin Flon, Manitoba. The company has indicated reserves of 1.3 million t grading 6.5 g/t to a depth of 300 m. Initial plans call for a 500 tpd operation with 65 employees at full production. Capital costs would be $15-20 million.

The La Ronge region of northern Saskatchewan continued as an active area of gold exploration and development. Saskatchewan Mining Development Corporation (SMDC) continued with the development of its joint venture Star Lake mine scheduled to start production in early-1987. Starrex Mining Corporation Ltd. holds a 35 per cent interest in the mine while Uranerz Exploration and Mining Limited holds the remaining 15 per cent. SMDC will operate the 220 tpd mill while the mining will be carried out by a contractor. Reserves are 230 000 t grading 15 g/t, sufficient to support the mine for three years with annual gold production of 1 120 kg.

The Jojay property, within 8 km of the Star Lake mine, has provided SMDC (66 per cent) and Claude Resources Inc. (34 per cent) with good signs of a high-grade deposit. A 2 000 m diamond drill program returned gold values of 10 g/t over mineable widths. The deposit is said to remain open along strike and at depth.

Claude Resources also holds 45 per cent of the Seabee property where exploration work by Placer Development Limited (55 per cent) has proved up more than one million t grading 10 g/t. Placer has until mid-1988 to decide whether to bring the property into production.

Blackdome Mining Corporation poured the first bar of dore from its Blackdome mine near Clinton, 240 km north of Vancouver, British Columbia. This is the province's newest gold-silver mine and has reserves of 200 000 t grading 24.6 g/t gold and 117 g/t silver. At a production rate of 200 tpd the mine has an expected life of four years with an average annual production of 1 400 kg of gold and 6 800 kg of silver.

Mascot Gold Mines Limited finalized a $70 million loan to develop its Nickel Plate mine near Hedley, British Columbia. Production is scheduled to start by mid-1987. The mine will be an open-pit and should reach its 2 700 tpd capacity and an annual gold production of 4 050 kg by 1988. Once in full production, the mine will be transferred to Mascot's parent company, Royex Gold Mining Corporation.

Total Erickson Resources Ltd. completed a major exploration program at its Cassiar operation in northern British Columbia and has discovered significant extensions to the complex vein system which it is mining. The company also completed a 300 tpd mill to replace the old mill which was destroyed by fire early in the year while under reconstruction. The mill feed is expected to average 12.4 g/t, and annual gold production should be 1 345 kg.

In the Yukon, AGIP Canada Ltd. (63 per cent) and Total Erickson Resources Ltd. (37 per cent) opened the $10 million Mt. Skukum mine at the end of July, the first successful major hard rock gold mine in the Territory. The mine is expected to produce 1 700 kg of gold per year from the 300 tpd mill. The deposit was originally discovered by AGIP in 1981 and Erickson earned its interest by bringing the deposit into production.

Canamax Resources Inc. and Pacific Trans-Ocean Resources Ltd. continued to evaluate the Ketza River gold deposit. Exploration has identified two ore zones, one with an oxide type ore and the other with a refractory type sulphide ore. Reserves of oxide ore total 500 000 t grading 15.9 g/t. The sulphide ore grades 8.7 g/t but reserves have not been accurately determined because of their refractory nature and lack of plans to mine the ore. The joint venture expects to spend at least $14 million to bring the deposit to production at 350 tpd, which would equal 2 000 kg of gold per year.

Several ownership changes occurred in the gold mining industry of the Northwest Territories. Pamour Inc. purchased Falconbridge Limited's 19.2 per cent interest in Giant Yellowknife Mines Limited and its 36.7 per cent interest in Akaitcho Yellowknife Gold Mines Limited for $16.9 million. Pamour then merged its active mining interests in the Timmins area and its interest in Akaitcho Yellowknife with those of Giant Yellowknife in return for $17.5 million and 2.7 million of Giant's treasury shares. Pamour's stake in Giant was thereby raised to 50.1 per cent. Gold production from Giant's amalgamated mining operations should total about 7 500 kg in 1986.

Echo Bay Mines Ltd. increased the reserve base at its Lupin mine when a development drift encountered ore in a lower extension of the main orebody. Detailed diamond drilling has not been completed but the company anticipated doubling its current reserves of more than 30 t of gold.

Cominco Ltd. announced the sale of its Con mine to NERCO Minerals Company for $64 million. The sale also included the arsenic trioxide processing plant and a small hydroelectric plant. The sale was part of Cominco's program to reduce corporate debt.

There are two major primary gold refineries in Canada. The largest is operated by the Royal Canadian Mint in Ottawa, where nearly 85 per cent of newly mined Canadian gold is refined to a purity of 99.99 per cent. Noranda Metal Industries Limited operates the CCR refinery in Montreal, Quebec. In addition to recovering gold from its base-metal operations, the CCR refinery also treats the dore bullion from the Giant mine at Hemlo.

Johnson Matthey Limited and Degussa AG both operate refineries in southern Ontario. These refineries also recover gold from secondary sources such as scrap and recycled jewellery.

WORLD DEVELOPMENTS

South African gold production is believed to have fallen in 1986 to 638 t, down from 672 t in 1985. One of the main reasons for the decline was an increased number of work stoppages. In addition, several gold mines experienced accidents such as explosions and underground fires. Some 180 miners died from poisonous fumes from a shaft fire at the Kinross mine. This was the worst accident in the history of gold mining in the country.

The United States replaced Canada as the world's third largest gold producer in 1986, after South Africa and the U.S.S.R. Gold production is estimated at 112 t, up from 80 t in 1985. The largest addition to U.S. gold production came from numerous heap leach mining operations which started production during the year. Several Canadian mining companies are active in United States gold production. Echo Bay Mines Ltd. spent about $5.5 million to bring the Sunnyside gold mine in Colorado into production at an annual rate of 1 560 kg. Echo Bay also holds a 50 per cent interest in the Round Mountain gold mine in Nevada which is expected to produce 4 300 kg a year.

Pegasus Gold Inc., active in the United States for several years, started up its Florida Canyon mine in Nevada at a cost of $14 million. This operation is expected to produce 1 650 kg of gold annually. The company also expects to start its Montana Tunnel mine in Montana in early-1987, to produce 3 300 kg gold and 53 000 kg of silver as well as lead and zinc.

Galactic Resources Ltd. began gold production from the Summitville mine in Colorado. The heap leach operation started commercial operation in June and was expected to produce 3 700 kg of gold in 1986.

Like other countries, Australia is making large additions to its gold production capacity and is estimated to have produced 75 t in 1986, up from 58 t in 1985. Output is forecast to exceed 100 t by 1988. Gold production at the Kidston mine in Queensland, the country's largest gold producer, was 7 300 kg in 1986. The Kidston mine, which is controlled by Placer Development Limited of Vancouver, began production in 1985.

In Western Australia, the Boddington gold project is being developed for production in late-1987. Annual gold output at capacity will be 5 100 kg, placing it second after Kidston.

Many other countries are expected to increase their gold output in the next few years, including Brazil, Papua New Guinea, the Philippines and Indonesia.

GOLD COINS

The bullion coin market received a boost when both the United States and Australia introduced bullion coins late in the year. The United States introduced the Eagle coin on October 20 and found that production of the coin could not keep up with the demand. The U.S. Mint was forced to allocate distribution to one day a week, and by December 12 had sold 1.04 million ounces of gold coins. If that rate can be maintained, the mint expects that sales will total 6.6 million oz (over 200 t) during the first 12 months. There is some concern that newly mined gold from U.S. producers will not be sufficient to meet the demand by the coin program and that gold from the Federal Reserve will be used to fill any shortfall. As a result, the Secretary of the Treasury, through a special provision, announced that gold for the coin program could be purchased from any GATT country. The provision is to be invoked only when newly mined U.S. gold is not available.

Australia took a different approach for 1986 by introducing only proof coins in the Nugget bullion series in order to first satisfy the numismatic coin market. The mass-produced bullion coin will be introduced internationally in early-1987. The sales target of the coin has been set at between 300,000 and 400,000 ounces, in the first twelve months. Sales of the Canadian Maple Leaf 24 carat gold coin were expected to total 1.5 million oz in 1986, down from 1.8 million oz in 1985.

GOLD PRICES

Gold prices recovered after three consecutive years of decline. The price began the year at the low point of $US 326, then increased gradually to reach the year's high of $US 442 in September. For the year the London Gold market morning and afternoon fixes averaged $US 368.

CONSUMPTION AND USE

The use of new gold for jewellery, coin and industrial purposes remained virtually unchanged in 1985 in the western world at 1 233 t, compared with 1 221 t in 1984. Gold demand was strong during the first quarter due to low gold prices, but fell dramatically with the sharp recovery in prices beginning in the second quarter.

In 1985, some 898 t of gold was fabricated into jewellery, an increase of over 10 per cent from the previous year. The gold markets of the United States, Japan and India showed the largest increases in demand.

Consumption of gold in the electronics industry fell almost 10 per cent in 1985 to 111 t, from 122 t in 1984. The main reason was an oversupply of computer components manufactured during the previous year. The situation was especially apparent in the United States where sales of home computers fell.

The market for gold in the dental industry remained steady in 1985, totalling 52 t. While this market has been stable for the past few years, the trend is towards substitution by non-gold alloys and ceramics which are cheaper and more natural in appearance.

OUTLOOK

Canadian gold mining production is expected to continue to increase over the next few years. Exploration activity continued at record levels in 1986 but rates after 1987 will depend on the continuation of the flow-through share program. This program resulted in over $500 million for investment in mineral exploration programs throughout Canada in 1986. While an actual breakdown is not available, it has been estimated that over 75 per cent of flow-through funds have been spent on gold exploration.

Several of the recently announced gold discoveries, such as those in the Casa Berardi region of Quebec, the La Ronge area of Saskatchewan and elsewhere across the country, have been at least partially funded by issues of flow-through shares. Many of these discoveries will result in additional gold output in the near future.

Gold prices in 1987 are expected to be in the $US 350-420 range. The current low inflation rate is expected to continue and be a limiting factor on increases in the price of gold. However, as always, there is the potential for unforeseen events to cause the price to vary outside of this range.

TABLE 1. CANADA, GOLD PRODUCTION AND TRADE, 1984-86

	1984	1985	1986P
		(grams)	
Production			
Newfoundland	35 120	-	-
New Brunswick	780 850	283 445	107 165
Quebec	28 531 550	30 103 798	29 464 000
Ontario	28 291 700	32 261 675	46 719 617
Manitoba	2 154 100	2 162 285	2 187 239
Saskatchewan	187 860	224 743	14 940
Alberta	16 440	28 460	25 000
British Columbia	7 656 250	6 720 050	8 737 000
Yukon	2 959 880	3 064 763	4 019 066
Northwest Territories	12 732 110	12 712 939	13 379 683
Total	83 445 925	87 562 158	104 654 510
Total Value ($Cdn)	1 252 283 179	1 219 653 297	1 715 391 647

	1984		1985		Jan.-Sept. 1986	
	(kilograms)	($000)	(kilograms)	($000)	(kilograms)	($000)
Imports						
Gold in ores and concentrates						
United States	238	3,563	206	2,510	340	4,884
Peru	156	1,965	113	1,380	109	1,420
Chile	112	1,440	-	-	-	-
Other countries	48	700	83	1,130	129	1,898
Total	554	7,668	402	5,020	578	8,202
Gold						
United States	48 382	748,450	69 652	973,400	54 867	872,630
Switzerland	758	11,395	539	7,520	348	5,297
West Germany	255	3,900	377	5,293	92	1,436
Other countries	41	750	45	1,237	13	254
Total	49 436	764,495	70 613	987 450	55 320	879,617
Gold alloys						
United States	11 846	167,660	17 845	206,707	26 705	321,672
Peru	2 449	37,735	1 555	19,603	-	-
Nicaragua	3 199	15,429	1 614	9,308	1 168	9,309
Papua New Guinea	306	3,137	4 801	51,121	-	-
Other countries	628	7,952	306	2,652	1 075	19,018
Total	18 428	231,913	26 121	289,391	28 948	349,999
Exports						
Gold in ores and concentrates						
Japan	4 002	46,522	5 193	56,292	4 483	54,931
United States	1 031	14,701	185	2,534	192	2,863
People's Republic of China	559	6,450	-	-	396	4,717
Switzerland	112	1,283	-	-	-	-
Other countries	666	8,118	590	5,888	310	3,727
Total	6 370	77,074	5 968	64,714	5 381	66,238
Gold						
United States	110 043	1,664,237	99 196	1,394,057	97 645	1,588,009
Japan	9 296	141,107	5 313	73,817	5 521	88,564
West Germany	446	7,584	340	4,809	92	-
Hong Kong	862	12,671	1 037	13,481	30	461
Panama	394	5,807	1 754	24,754	539	8,367
Other countries	631	9,474	804	11,126	1 381	21 935
Total	121 672	1,840,880	108 449	1,522,044	105 116	1,707,336
Gold alloys						
United States	122	1,030	1 495	17,664	3 343	40,853
Trinidad-Tobago	281	2,245	178	1,293	22	225
West Germany	2 084	30,289	2 561	31,470	1 038	14,226
Other countries	8	77	15	130	254	3,538
Total	2 495	33,641	4 249	50,557	4 657	58,842

Sources: Energy, Mines and Resources Canada; Statistics Canada.
P Preliminary; - Nil.

TABLE 2. CANADA, GOLD PRODUCTION BY SOURCE, 1970, 1975 AND 1979-85

	Auriferous Quartz Mines		Placer Operations		Base-Metal Ores		Total	
	(grams)	(%)	(grams)	(%)	(grams)	(%)	(grams)	(%)
1970	58 591 610	78.2	228 890	0.3	16 094 525	21.5	74 915 025	100.0
1975	37 529 456	73.0	335 077	0.6	13 568 581	26.4	51 433 114	100.0
1979	33 794 332	66.1	899 202	1.7	16 448 825	32.2	51 142 359	100.0
1980	31 928 594	63.1	2 059 727	4.0	16 631 942	32.9	50 620 263	100.0
1981	35 876 992	69.0	1 632 720	3.1	14 524 569	27.9	52 034 281	100.0
1982	47 865 658	74.0	2 476 468	3.8	14 393 104	22.2	64 735 230	100.0
1983	55 521 686	75.5	3 235 019	4.4	14 755 774	20.1	73 512 482	100.0
1984	62 553 528	75.0	3 393 003	4.1	17 499 394	20.9	83 445 925	100.0
1985	67 241 163	76.8	3 463 684	4.0	16 857 311	19.2	87 562 158	100.0

Sources: Statistics Canada; Energy, Mines and Resources Canada.

TABLE 3. CANADA, GOLD PRODUCTION, AVERAGE VALUE PER GRAM AND RELATIONSHIP TO TOTAL VALUE OF ALL MINERAL PRODUCTION[1], 1970, 1975 AND 1979-86

	Total Production	Total Value	Average Value per Gram[1]	Gold as Per cent of Total Value of Mineral Production
	(grams)	($Cdn)	($Cdn)	(per cent)
1970	74 915 025	88,057,464	1.18	1.5
1975	51 433 114	270,830,389	5.27	2.0
1979	51 142 359	590,766,328	11.55	2.3
1980	50 620 263	1,165,416,873	23.02	3.7
1981	52 034 281	922,089,087	17.72	2.9
1982	64 735 230	968,012,000	14.95	2.9
1983	73 512 482	1,230,886,000	16.74	3.3
1984	83 445 925	1,252,283,179	15.01	2.9
1985	87 562 158	1,219,653,297	13.93	2.7
1986[e]	104 654 150	1,715,391,647	16.39	2.8

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Value not necessarily based on average annual gold price.

[e] Estimate.

TABLE 4. GOLD MINE PRODUCTION IN THE NON-COMMUNIST WORLD

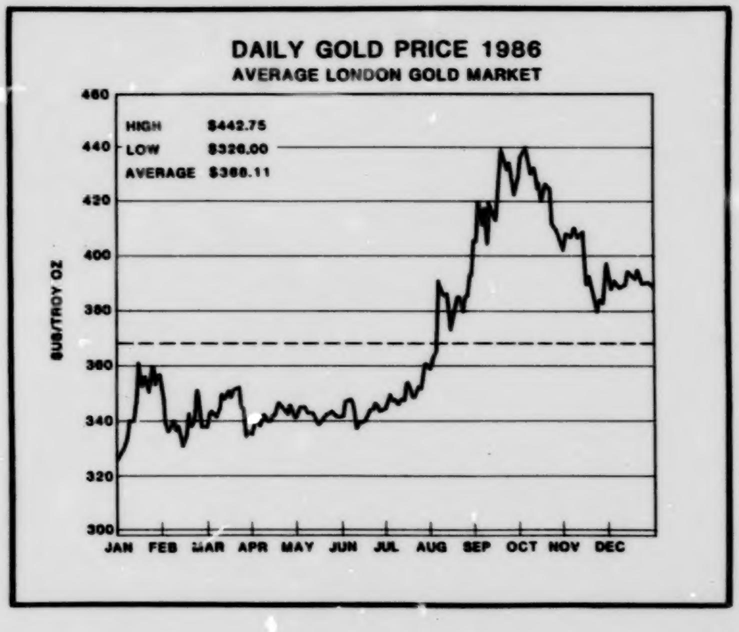
	1975	1980	1981	1982	1983	1984	1985
				(tonnes)			
South Africa	713.4	675.1	657.6	664.3	679.7	683.3	673.3
Canada	51.4	50.6	52.0	64.7	73.5	83.4	87.5
United States	32.4	30.2	42.9	45.0	60.9	68.5	79.0
Other Africa:							
Ghana	16.3	10.8	11.6	12.0	11.8	11.6	12.0
Zimbabwe	11.0	11.4	11.6	13.4	14.1	14.5	14.7
Zaire	3.6	3.0	3.2	4.2	6.0	10.0	8.0
Other	1.5	8.0	12.0	15.0	15.0	15.0	17.0
Total Other Africa	32.4	33.2	38.4	44.6	46.9	51.1	51.7
Latin America:							
Brazil	12.5	35.0	35.0	34.8	58.7	55.1	63.3
Colombia	10.8	17.0	17.7	15.5	17.7	21.2	26.4
Dominican Republic	3.0	11.5	12.8	11.8	10.8	10.6	10.4
Chile	4.1	6.5	12.2	18.9	19.0	18.0	18.2
Peru	2.9	5.0	7.2	7.2	9.9	10.5	10.2
Mexico	4.7	5.9	5.0	5.2	7.4	7.5	7.7
Nicaragua	1.9	1.5	1.6	2.9	1.7	1.5	1.5
Other	1.9	5.9	8.1	9.0	16.5	18.1	25.0
Total Latin America	41.8	88.3	99.6	105.3	141.9	142.5	162.7
Asia:							
Philippines	16.1	22.0	24.9	26.0	33.3	34.1	38.5
Japan	4.8	3.4	3.3	3.6	3.4	3.5	4.9
India	3.0	2.6	2.6	2.2	2.2	2.0	1.7
Other	2.7	4.5	4.6	5.2	5.3	5.9	7.2
Total Asia	26.6	32.5	35.4	37.0	44.2	45.5	52.3
Europe	11.0	11.8	11.9	12.4	14.1	15.0	15.1
Oceania:							
Papua/New Guinea	17.9	14.3	17.2	17.8	18.4	18.7	33.2
Australia	16.3	17.0	18.4	27.0	30.6	39.1	57.0
Other	2.2	1.0	1.1	1.2	1.8	1.8	2.5
Total Oceania	36.4	32.3	36.7	46.4	50.8	59.6	92.7
TOTAL	945.7	954.4	976.7	1 025.1	1 112.0	1 148.9	1 212.8

Source: Consolidated Gold Fields PLC, Gold 1985, p. 16.

TABLE 5. ANNUAL GOLD PRODUCTION, 1979-86 AND FORECAST TO 1990

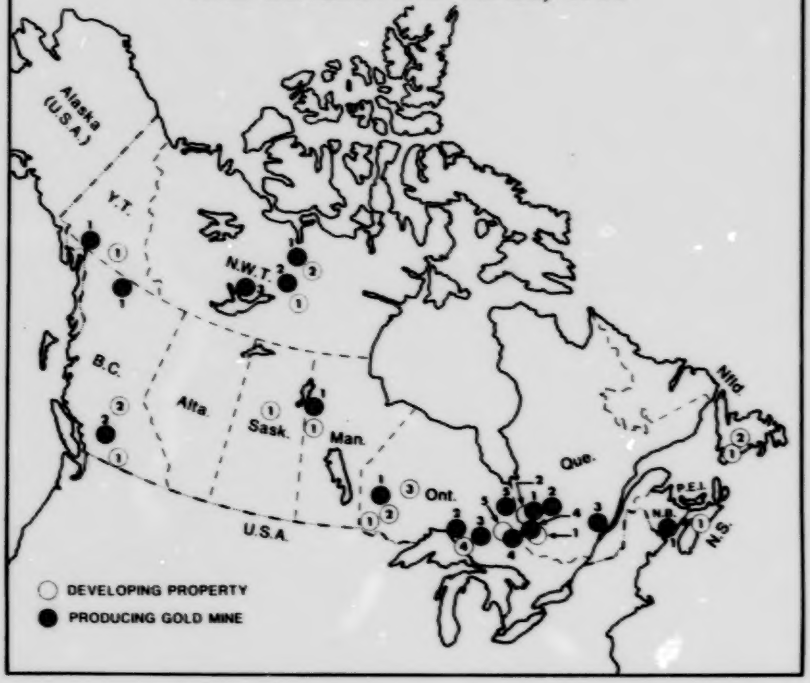
	Non-communist World[1],[2]	Canada
	(tonnes)	
1979	1 153.9	51.1
1980	1 029.5	50.6
1981	1 234.8	52.0
1982	1 231.7	64.7
1983	1 265.9	73.5
1984	1 280.0	83.4
1985	1 310.0	87.6
1986P	1 315.0	104.7
1987f	1 315.0	110.0
1988f	1 310.0	120.0
1989f	1 310.0	125.0
1990f	1 310.0	130.0

[1] Mine production; does not include recycled material. [2] Market economy country production plus sales from East Bloc Countries.
P Preliminary; f Forecast.



DAILY GOLD PRICE 1986
AVERAGE LONDON GOLD MARKET

PRINCIPAL CANADIAN GOLD PRODUCERS AND DEVELOPING MINES, 1986


Alaska (U.S.A.)
Y.T.
N.W.T.
B.C.
Alta.
Sask.
Man.
Ont.
Que.
Nfld.
P.E.I.
N.B.
N.S.
U.S.A.
○ DEVELOPING PROPERTY
● PRODUCING GOLD MINE

MAJOR PRIMARY CANADIAN GOLD PRODUCERS, 1986

Yukon Territories:

1. Total Erickson Resources Ltd. - Mt. Skukum mine

Northwest Territories:

1. Echo Bay Mines Ltd. - Lupin mine
2. Giant Yellowknife Mines Limited - Salmita mine
3. Giant Yellowknife Mines Limited - Giant mine
   NERCO Minerals Company - Con mine

British Columbia:

1. Total Erickson Resources Ltd. - Cassiar
2. Kerr Addison Mines Limited/Blackdome Mining Corporation
   Blackdome Project

Manitoba

1. SherrGold Inc. - MacLellan mine

Ontario:

1. Red Lake Area
   - Campbell Red Lake Mines Limited
   - Dickenson-Sullivan Joint Venture
2. Hemlo Area
   - Lac Minerals Ltd. - Page-Williams mine
   - Noranda Inc./Golden Giant Mines Ltd./Golden Sceptre Resources Ltd. Joint Venture - Golden Giant mine
   - Teck-Corona Operating Corporation - David Bell mine
3. American Barrick Resources Corporation/Royex Gold Mining Corporation
   - Renabie mine
4. Timmins - Kirkland Lake Area
   - Dome Mines, Limited - Dome mine
   - Pamour Inc. (Jimberlana Minerals NL) - Pamour #1, Timmins and Ross mines
   - Kidd Creek Mines Ltd. (Falconbridge) - Owl Creek, Hoyle Pond
   - Lac Minerals Ltd. - Macassa, Lake Shore mine
   - Kerr Addison Mines Limited - Kerr Addison mine
   - Inco Limited/Queenston Gold Mines Limited Joint Venture - McBean mine
5. Campbell Red Lake Mines Limited/Amoco Canada Petroleum Company Ltd. Joint Venture - Detour Lake mine

Quebec:

1. Agnico-Eagle Mines Limited - Telbel mine
2. Bachelor Lake Gold Mines Inc.
   Corporation Falconbridge Copper - Lac Shortt mine
3. Muscocho Explorations Limited - Montauban mine
4. Noranda/Rouyn - Val d'Or Area
   - Lac Minerals Ltd. - Doyon mine/Bousquet mine
   - American Barrick Resources Corporation - Camflo
   - Belmoral Mines Ltd. - Belmoral mine
   - Kiena Gold Mines Limited - Kiena mine
   - Sigma Mines (Quebec) Limited - Sigma mine
   - Louvem Mining Company Inc. - Chimo mine

New Brunswick:

1. Gordex Minerals Limited - Cape Spencer mine

DEVELOPING PROPERTIES IN CANADA, 1986

Yukon Territories:

1. Canamax Resources Inc./Pacific Trans-Ocean Resources Ltd.
   Ketza River Property

Northwest Territories

1. Terra Mines Ltd. - Bullmoose Project
2. Echo Bay Mines Ltd./Petromet Resources Limited - Kim/Cass Project

British Columbia

1. Mascot Gold Mines Limited/International Corona Resources Ltd. -
   Nickel Plate mine
2. Serem Inc. - Lawyers Project

Saskatchewan

1. La Ronge Area
    - SMDC/Starrex Mining Corporation Ltd. - Star Lake mine
    - Canadian Premium Resource Corporation/Mahogany Minerals Resources Inc.
      Jolu Project
    - Placer Development Limited/Claude Resources Inc. - Seabee Project

Manitoba

1. Grănges Exploration AB/Abermin Corporation - Tartan Lake mine
   Grănges Exploration AB/Maverick Mountain Resources Limited
   - Puffy Lake Project

Ontario

1. Consolidated Professor Mines Limited - Duport
2. Echo Bay Mines Ltd./Nuinsco Resources Limited - Cameron Lake
3. Dome Mines, Limited/Campbell Red Lake Mines Limited - Dona Lake
   St. Joe Minerals Corporation - Golden Patricia
4. MacMillan Energy Corp., Grănges Exploration Ltd. - Mishibishu Lake
   Canamax Resources Inc./Kremzar Gold Mines, Limited - Kremzar
5. Timmins - Kirkland Lake Area
    - Canamax Resources Inc./Consolidated CSA Minerals Inc. - Bell Creek
    - Getty Mines, Limited/Davidson Tisdale Mines Limited - Davidson Tisdale mine
    - Diepdaume Mines Limited - Diepdaume mine
    - Canamax Resources Inc./Bruneau Mining Corporation - Clavos Project
    - St. Andrew Goldfields Ltd. - St. Andrews mine

Quebec

1. Noranda/Rouyn - Val d'Or Area
    - Dumagami Mines Limited - East & West Zones
    - D'Or Val Mines Ltd. - Beacon mine
    - Belmoral Mines Ltd. - Bourlamaque mine
    - Louvem Mining Company Inc. - North Pascalis
2. Casa Berardi Area
    - Inco Limited/Golden Knight Resources Inc. - Golden Pond Project
    - Teck Corporation/Golden Hope Resources Inc. - Estrades Project

Nova Scotia

1. Seabright Resources Inc. - Beaver Dam mine
   Seabright Resources Inc. - Forest Hill mine

Newfoundland

1. Hope Brook Gold Inc. - Chetwynd mine
2. Westfield Minerals Limited - Joint Venture

Graphite

M. PRUD'HOMME

SUMMARY

There was no Canadian production of graphite in 1986 as the only operation, Asbury Graphite Quebec Inc., has undertaken a modernization program. Reported consumption of graphite in 1985 decreased by 5 per cent from 1984 to 12 013 t, of which 8 896 t were natural graphite. Amorphous graphite accounted for 42 per cent and was used mainly by the metallurgical industry. Flake graphite was used in foundries and refractories while synthetic graphite was consumed by foundries and abrasive industries.

Imports of crude graphite for the first nine months of 1986 amounted to $2.2 million, an increase of 36 per cent compared with the same period last year. In 1985, imports of crude graphite were shipped into Ontario (74 per cent) and Quebec (16 per cent).

The United States accounts for 90 per cent of total Canadian crude graphite imports. Other supplying countries include West Germany, Madagascar, Switzerland, Hong Kong and China.

During 1986, active development work occurred in Ontario and Quebec while exploration programs were carried out in Alberta, Quebec, New Brunswick and Nova Scotia. Cal Graphite Corporation in Butt township (Ontario) and Princeton Resources Corporation in Maria township (Ontario) conducted processing tests for crystalline flake graphite concentrates. Decisions on these projects are expected to be made in 1987, following the results of feasibility studies. Both companies anticipate to produce graphite concentrate suitable for crucibles, refractories and lubricants in American and West European markets. Stratmin Inc. in Lochaber Township, Quebec, will be conducting a feasibility study to evaluate the potential of a graphite deposit near the Municipality of Mayo.

Prices for natural graphite remained relatively stable in 1986 with a slight 5 per cent increase particularly for the crystalline flake grade. Supplies are still sufficient to satisfy worldwide demand; however, demand is shifting from small flake to high carbon powdered graphite and to ultra high purity graphite products.

Demand for crystalline graphite is highly dependent on the performance of the steel industries and foundries. Substitution between graphite concentrates leads to demanding technical requirements from customers. New producers will encounter difficulties in finding markets, especially for low-grade natural graphite powders which are usually co-produced in the processing of high quality flake graphite products.

Market conditions are favourable in Western Europe and in the United States, while the Japanese market is highly dependent on South Korea and on China which is committed to major capacity expansions over the next five years.

NATURAL GRAPHITE

Graphite is a natural form of carbon. Natural graphite is a lustrous, black carbon mineral, crystallized in the hexagonal system with rhombohedral symmetry. Flake graphite is opaque, flexible and sectile, and exhibits perfect basal cleavage. Natural graphite is unctuous and is relatively soft with a hardness of 1 to 2 on Mohs' scale. It has a black colour and a black streak on glazed porcelain. Its specific gravity is 2.266 g/cm^3. Graphite is an excellent conductor of heat and electricity, and it has a high melting temperature of 3 000°C. It is extremely resistant to acid, chemically inert and highly refractory.

Natural graphite is widely distributed throughout the world and is of common occurrence in metamorphic rocks produced by regional or contact metamorphism.

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Amorphous graphite is a microcrystalline graphite formed by crystallization of the carbon from organic sediments such as coal. The graphite occurs as distorted seams of minute microcrystalline particles intermixed with ungraphitized materials. The graphite content may vary from 15 per cent to 98 per cent, depending on the degree of metamorphism and the original carbon content in the sediments. Crystalline lump, or vein graphite, occurs in the form of massive vein or circular accumulation formed probably from hydrothermal origin. The graphite occurs along the contacts of intrusive rocks with limestones. Such occurrences appear in foliated or columnar forms. Crystalline flake graphite is found disseminated in metamorphosed siliceous or calcareous sediments such as marble, gneiss and schist.

Commercially, natural graphite is classified as crystalline flake or amorphous graphite depending on its particle size. Crystalline flake is defined as thin flakes which could be classified from coarse to fine and which are graded according to their graphitic carbon content. Amorphous grade is applied to microcrystalline graphite sold for low-value uses such as foundry facings. It is graded on graphitic carbon content which may vary between 50 per cent and 90 per cent carbon.

Graphite is also termed as plumbago, black lead, silver lead, carburet of iron, potelot, crayon noir, carbo mineralis and reissblei.

Graphite is considered as a strategic mineral which is defined as a mineral that is largely or entirely supplied by a foreign source, that is difficult to substitute, and that is important to a nation's economy.

SITUATION IN CANADA

Occurrences

Graphite deposits in Canada occur principally in rocks of the Grenville series of eastern Canada. The mineral is found in disseminated crystalline flake and vein forms. Most Canadian graphite deposits are associated with graphite gneiss and crystalline limestones which have been subjected to contact metamorphism associated with tectonic features such as folding, compression and fracturing, and with pegmatitic intrusions. The richest ore zones occur as a succession of veins or lenticular bodies that gradually merge into the adjacent non-graphititic host rock and that are bordered by lenses of lower-grade ore.

Flake graphite deposits have been reported mainly in New Brunswick, Nova Scotia, Quebec, Ontario, and Saskatchewan.

In New Brunswick, graphite deposits found in limestone have been worked near Split Rock and Marble Cove in Lancaster Parish. The graphitic bands occur in argillites and sub-crystalline limestones and may vary from 0.3 to 3 m in thickness. Graphite is associated with pyrite.

In Nova Scotia, graphite occurrences were recorded in Cape Breton, in crystalline limestones, shales and slates which are intruded by granite. The largest occurrence is located near Glendale, Inverness County, where microcrystalline graphite occurs.

In Quebec, graphite deposits are located mainly along the Grenville series in several townships: Buckingham, Argenteuil and Pontiac. The disseminated flake graphite variety is dominant, in biotite gneiss and crystalline limestone associated with biotite quartzite, but the vein variety is also reported along the contact of intrusive rocks and crystalline limestone. Occurrences of graphite are associated with metasedimentary rocks which have been subjected to several deformation phases and where metamorphism has reached amphibolitic or granulitic phases.

In Ontario, graphite deposits occur within crystalline limestone and gneiss. The occurrences of major interests are in semi-pelitic and pelitic gneiss units within paragneiss sequences. Graphite is present in amounts up to 10 per cent and grain sizes may vary from 2 to 10 mm. Accessory minerals consist of biotite, garnet and pyrite; trace elements in these graphitic rocks are nickel, cobalt, boron and vanadium.

In northern Saskatchewan, graphite ore in coarse-grain biotite-gneiss occurs near the southwestern shore of Deep Bay near Reindeer Lake. The mineralized area is several miles long and contains about 10 per cent carbon. Reserves are estimated at about 3 million t.

Production, Exploration and Development

In 1986, no production of graphite was recorded in Canada, even from the intermittent producer in Quebec. However, several development activities were recorded in Ontario and in Quebec.

In Quebec, a graphite open-pit mine near Notre-Dame-du-Laus has been operating since 1980 by Asbury Graphite Quebec Inc. The ore is a disseminated flake graphite in crystalline limestone associated with biotite quartzite. Graphite ore grades between 7 to 12 per cent carbon content, averaging 9.5 per cent carbon. Reserves are estimated at 600 000 t. Since 1984, a modernization program has been undertaken at a cost of $800,000 to expand capacity by 20 per cent and reduce operating costs by 25 per cent. Asbury Graphite Quebec Inc. will continue to produce flaky graphite in three sizes when operations resume in 1987: -40 mesh, -40 + 100 mesh, and -100 mesh, with carbon content above 85 per cent.

In 1984, Orrwell Energy Corporation was developing a graphite deposit near Mont-Laurier in Quebec. The project has been suspended due to legal complications. During 1986, all Orrwell assets were transferred to a new company named Harkema Industries Limited. In Lochaber Township, Bay Resources and Services Inc. carried out a diamond drilling program during 1986. The drilling work has identified mineralized zones with graphite ore grading between 7.49 per cent and 17.76 per cent carbon. The width of the zones ranges from 3.66 m to 4.27 m. The claims were bought in 1986 from Lochaber Plumbago Mines et Exploration Inc. At the end of 1986, all the graphite interests of Bay Resources and Services Inc. were transferred to Stratmin Inc. which will undertake further exploration in western Quebec.

In Ontario, development activities were carried out mainly in eastern Ontario. Princeton Resources Corporation, a Vancouver-based Canadian company, is developing a flake graphite deposit near Bissett Creek. Since 1984, the company has drilled 106 holes for a total of 5 500 m delineating reserves that have been estimated by the company at close to 10 million t; the graphite ore averages between 3.5 per cent and 5 per cent carbon content. A feasibility study will be conducted on a mining and processing operation. Capital costs of a 13 600 tpy processing plant are estimated at $7 million. Graphite concentrates grading from 85 per cent to over 95 per cent carbon content should be produced for sale in both local and foreign markets. An exclusive five-year marketing arrangement has been concluded with Kloeckner and Co. of West Germany. Late in 1986, Princeton Resources Corporation offered an option on its subsidiary which owns the graphite deposit; conditions to this option are the completion of the pilot plant before May 1987 and operation of the pilot plant.

Cal Graphite Corporation of Lively holds a 100 per cent interest in mining claims in the Township of Butt where crystalline flake graphite occurs in mafic gneiss and paragneiss. Since 1985, Cal Graphite Corporation has undertaken exploration work, including 56 diamond drill holes, trenching, stripping, and sampling. Proven reserves were estimated at 7 million t of graphite ore, grading an average of 2.5 per cent graphite carbon measured by double ignition loss. Late in 1986, the company was expecting to make a project decision on an open-pit mine and on a processing plant with a production capacity of 40 000 tpy of graphite concentrate. Construction could start by May 1987 and full production could be reached by the spring of 1988. The project will require an investment of around $7 million and could create about 30 jobs. The flake graphite concentrates averaging 92 to 94 per cent carbon will be sold to crucibles, lubricants and refractories companies, mainly in the United States.

In eastern Ontario, several other activities were undertaken on potential graphite projects. Market appraisals and exploration work were carried out on deposits in Ryerson and Bastard Townships.

Exploration activities also occurred in several provinces where graphite deposits had already been investigated. In Saskatchewan, a small exploration program was carried out on the Deep Bay property to define the mineral potential. In New Brunswick, Glenvet Resources carried out analytical work on graphite ore samples from its Golden Grove graphite property. In Nova Scotia, microcrystalline graphite and some flake graphite occur in schistose rock in Inverness County where large graphite reserves have been identified.

In 1986, the CANMET Mineral Processing Laboratory in Ottawa initiated two in-house studies to determine the quality of several graphitic ores sourced from prospective deposits. The first study will determine the graphitic content of samples through different assaying methods and will evaluate the previous mineralogical work on these samples with the collaboration of industry. The second study will determine optimum grinding and sizing techniques for quick recovery of coarse flake graphite from the most promising sources. The objectives of these studies are to evaluate the potential for development of graphitic ore resources based on technological assessment and to ensure that these technologies are accessible to potential producers.

For further information on graphite R&D, contact J.M. Lamothe at CANMET (tel. 613-992-1219).

USES AND SPECIFICATIONS

The uses of natural graphite depend on its physical and chemical properties. The strength of graphite increases as its temperature rises. It has a high thermal conductivity and a low absorption coefficient for X-rays and electrons. Flake graphite enhances anisotropy in bodies where forming processes, such as extrusion and pressing, align the flakes. It resists oxidation better than granular graphite.

Flake graphite is used in the manufacture of crucible for the steel, nonferrous and precious metals industries. It is preferred to microcrystalline graphite because it burns more slowly, has a high attrition resistance and imparts structural strength through the orientation of the flakes. For this application, graphite must be of large flake size, above 300 microns, with a carbon content of 90 per cent, although finer flake size with a carbon content in the range of 80 to 90 per cent is also used.

In ramming mixes, graphite imparts high refractoriness, low thermal expansion and high resistance at elevated temperature. Microcrystalline graphite of high purity, 80 to 95 per cent carbon is required.

Carbon refractories are classified as including more than 7 per cent carbon in a blend with either microcrystalline or flake graphite, and are known as magnesia carbon brick. Mag-Carbon brick is used in high temperature and corrosion prone applications such as in steel furnace lining, ladles, slag-lines, hotpots, nozzles and blast furnace. Graphite is used because of its thermal conductivity, and thermal and chemical resistances. Flake graphite must have a carbon content between 90 and 97 per cent and sizes ranging from 75 to 180 microns. Amorphous graphite is also used with carbon content of around 70 and 80 per cent and size larger than 600 microns. Size of flakes is important but not as critical as the degree of compaction of the bricks and shapes. Porosity needs to be minimal.

The use of graphite in brake linings reduces the wear rate. High carbon fine crystalline graphite, below 75 microns, is used with a minimum carbon content of 98 per cent, although a concentrate of 90 per cent can be used if abrasive impurities such as silica are at a low level.

Traditionally, graphite has been used in dry cell zinc-carbon batteries due to its electrical conductivity. Fine grain carbon, below 75 microns, or microcrystalline graphite with a minimum carbon content between 85 to 90 per cent is required. Alkaline batteries require a purer natural graphite with a carbon content of at least 98 per cent or a synthetic grade. Carbon material should be free of metallic impurities such as copper, cobalt or antimony.

Electric motor components use a wide variety of graphite, natural or synthetic. Powdered graphite, 150 microns, with a minimum carbon content of 95 to 99 per cent is used. Lump graphite, low-silica microcrystalline graphite and synthetic graphite are usually utilized.

In powder metallurgy where steel is reinforced by the absorption of carbon, high purity graphite is required for the sintering. It also acts as a lubricant and as a source of carbon. Dry powder graphite should be of an average particle size of 5 microns and must have a carbon content between 96 to 99 per cent.

Lubricants for industrial usage are also made from graphite because of its softness, low friction, inertness and heat resistance. High carbon fine crystalline graphite, below one micron, is specified with a carbon content of 96 to 99 per cent.

In paint manufacture, graphite is used to protect metal surfaces exposed to corrosive environment, and to eliminate the accumulation of static electricity in floor coating. Microcrystalline graphite of low carbon content, 50 to 55 per cent, is usually required.

In the manufacture of lead pencil, natural graphite is used because of its marking properties. The degree of hardness of a pencil is determined by the clay to graphite ratio of its lead. Microcrystalline graphite, 80 to 82 per cent, is used in the cheaper grades of leads. However, a finely ground graphite with a higher carbon content, over 90 per cent, is usually required.

For foundry application such as mould coating, graphite prevents the adhesion of metals. Foundry facings are usually made of lump graphite or microcrystalline graphite, between 53 to 75 microns, with a low carbon content, 40 to 70 per cent.

Iron foundries use microcrystalline graphite as a recarburizer for raising the carbon content of iron melted in electrical furnace from charges containing large proportions of scrap. A wide variety of material may serve as a substitute: synthetic graphite and coke.

Other uses for natural graphite include engineering components, mechanical seals, polishes, rubber products and explosives.

For any usage, consumers should require only minimal specifications necessary in their operation because of the prices of all types of graphite commercially available.

The graphite content of graphitic ore is crucial when evaluating the potential of a deposit. Several methods of assaying are currently used: simple ignition loss, double ignition loss and double ignition loss with oxidization control. Simple ignition loss method consists in simultaneous complete oxidization and calcination of samples. The second method comprises a first-phase ignition loss which consists in the calcination of carbonates and the oxidization of organic carbon, followed by a second-phase ignition loss of graphitic material at high temperature. The third method is similar to the second method, except that during the first calcination, the absence of oxygen prevents premature oxidization of the graphite.

CANADIAN PRODUCTION, CONSUMPTION AND TRADE

Canada does not produce microcrystalline graphite but has been producing small quantities of crystalline flake graphite on an intermittent basis. For 1986, there has been no recorded production and all shipments were from stocks.

Reported consumption of graphite in 1985 amounted to 12 013 t, a 5 per cent decrease from 1984 levels. Natural graphite accounted for 74 per cent of which 42 per cent was amorphous graphite. Crystalline flake graphite was mainly used in foundries and refractories while amorphous graphite was used principally by the metallurgical industry. Synthetic graphite accounted for 26 per cent of total reported consumption and was mainly used in foundries and abrasives.

In 1985, the value of imports of crude graphite rose by 19.5 per cent as a result of exchange rate increases. The United States accounted for 91 per cent of Canadian imports. Crude graphite was imported mainly into Ontario (74 per cent) and Quebec (16 per cent). On a nine-month basis in 1986, the value of imports of crude graphite increased by 36 per cent in current dollars, compared to the same period in 1985; the United States accounted for 90 per cent of total value. Other supplying countries are: West Germany, Madagascar, Switzerland, Hong Kong and China.

WORLD PRODUCTION AND REVIEW

In 1985, world production was 613 800 t for all types of natural graphite, of which half was powdered graphite. The major producers remain China with 185 000 t; the U.S.S.R., 86 000 t; Czechoslovakia, 59 000 t; and Austria, 40 000 t. Over the last two years, Brazil has increased its production by 97 per cent (flake), South Korea by 87 per cent (amorphous) and Zimbabwe by 66 per cent (amorphous).

United States

Natural graphite was not produced in 1986. Apparent consumption of natural graphite in 1985 was estimated at 38 620 t, an increase of 21 per cent over 1984. Refractories account for 20 per cent of total flake graphite consumption and 35 per cent of total amorphous consumption. Other major usages were for foundries (19 per cent), crucibles (12 per cent, flakes), brake linings (10 per cent), lubricants (10 per cent), pencils (6 per cent) and steelmaking (6 per cent, amorphous). In the period 1980 to 1985, the share of imports in apparent consumption ranged between 78 and 88 per cent, with an average of 83.7 per cent. In 1985, U.S. imports dropped by 9.4 per cent to 47 830 t, valued at $US 16,186,000. However, imports of crystalline graphite declined by 45 per cent compared to 1984 tonnages. Microcrystalline (amorphous) graphite accounted for 40 per cent of total imports in terms of tonnage, and 7 per cent in terms of value. Flake graphites were mainly imported from China which accounted for 42 per cent of total flake tonnage, followed by Brazil (22 per cent) and Madagascar (10 per cent).

Graphite prices in 1985, as measured by the unit value of imports, averaged $US 536 per short ton for crystalline graphite, an increase of 5 per cent compared to 1984. Mexican amorphous graphite reached $US 50 per short ton in 1985.

The joint venture between Black Diamond and Medallion Minerals conducted development work at the Black Diamond Graphite property in Broadwater County.

Superior Graphite Co. Ltd. announced an expansion plan to produce more than 32 000 tpy of carbon additives at the Hopkinsville plant in Kentucky. Started in April 1986, this project will cost $US 2.2 million and will be completed in February 1987.

United Minerals Co. ceased operations in 1985 at the amorphous graphitic open-pit mine, near Townsend, Montana.

China

As reported by the U.S. Bureau of Mines, the Chinese government plans to increase its involvement in the development of three graphite mines to produce around 250 000 tpy of graphite by 1990.

Norway

In April 1985, the graphite processing plant of Skaland Grafiwerk was destroyed by fire. The firm announced in 1986 that a new processing facility will be completed by year-end 1987. Annual production capacity is expected to be about 8 000 to 10 000 t of which 60 per cent will be graphitic concentrate averaging 98 per cent carbon.

Pakistan

The Azad Kashmir Minerals and Industrial Development Corp. has discovered large deposits of cryptocrystalline graphite in the Muzaffarabad District. Proven reserves amounted to 1 million t of graphite ore. Concentrates of 84 per cent graphite content have been achieved on a pilot plant scale.

INTERNATIONAL TRADE AND MARKET

Although graphite occurrences are widespread and many potentially important deposits are undeveloped, the international trade in graphite represents a relatively small market. Few countries supply natural graphite and production is usually limited to one major category. Small volumes of graphite are consumed by producers.

China became the principal natural graphite exporter and an important source of supply for Japan, the United States and the United Kingdom. South Korea is the second major supplier with all exports going to Japan. Other major exporting countries are: Madagascar, Austria, North Korea and Brazil. Sri Lanka is the only major supplier of crystalline vein graphite. The world's largest importer is Japan followed by the United States, West Germany and the United Kingdom.

Security and diversification of supplies are of concern for many consuming nations which are attempting to substitute different types of graphite and to locate new secure sources of supply. Political developments, exhaustion of reserves and operational problems are adversely affecting production in traditional producing and exporting countries. These realignments between users and suppliers present opportunities for potential new suppliers such as Canada.

Market in 1985

In 1985, demand for natural graphite grew on a world basis due to better performance in consuming industries. However, the usage of amorphous and crystalline graphite declined in North America due to reduced activities in the steel and refractories industries. Flake crystalline graphite continued to be in demand for magnesia-carbon refractories. Graphite markets might become tighter as technical requirements for flake graphite will have to meet stricter specifications from customers. Demand for small flakes is expected to shift to high carbon powder grade while ultra-high purity graphite is substituting other forms of carbons containing higher levels of impurities, in the manufacture of batteries, crucibles, refractory bricks, lubricants and brake linings.

China expanded its worldwide market share, especially in the United States with 27 per cent of total imports and in Japan with 41 per cent, maintaining Japan's reliance on China's flake imports (90 per cent).

PRICE

Published prices for natural graphite provide only a range of prices and are not representative of market prices which are contracted prices negotiated between suppliers or distributors and consumers. The prices of flake graphite and vein graphite are higher than those for microcrystalline or amorphous graphite because of the nature of mining and processing operations. Prices for flake graphite concentrate vary depending on the carbon content, the size of the flake and their distribution.

Amorphous graphite prices have dropped slightly due to reduced demand and ranged from $US 42 to $84 per t in the United States. Prices for crystalline flake graphite have increased by 5 per cent in 1986, as price levels were influenced by low-priced Chinese and Mexican products.

OUTLOOK

The U.S. Bureau of Mines has estimated that the demand for natural graphite is expected to increase at an average annual rate of about 1.5 per cent for the period 1983-2000 from 573 200 t to 743 740 t. American consumption of crystalline flake graphite is forecast at 26 300 t in the year 2000, and nearly 30 800 t for microcrystalline graphite. Demand for natural graphite will be limited due to technological shifts towards the use of plasma arc furnace and the availability of alternative materials. Anticipated declines in demand for microcrystalline will be slightly offset by growth in crystalline flake usage.

The refractory industry is the largest single consumer of natural graphite and will remain dependent on the iron and steel industry. Stronger demand for graphite is expected in continuous casting, batteries and pencils. Demand in steelmaking and foundries will remain steady or decline slightly due to strong competition from alternative materials. Demand for graphite in brake linings will be increasing as an alternative to asbestos-based products. The current trend in the graphite industry is towards higher purity products, free of both impurities and abrasive materials. The introduction of a thermally purified, high-purity crystalline flake graphite will maintain the demand for natural graphite in refractories and curb the substitution by synthetic graphite. Hybrid graphite products are being developed for high performance refractories. Hybrid products consist of graphite material blended with oxidation inhibitors (5 to 15 per cent by weight) for improving the oxidation resistance to air and carbon dioxide.

North America will remain largely dependent on foreign sources for graphite. Although some grades of graphite are in limited supply, world production is more than sufficient to supply the demand for natural graphite. China should continue to be the world's major supplier with emphasis on capacity and low prices. The availability of the low-cost, high-grade graphite could be affected by the policies of foreign governments in supplying countries. Should this happen, development of alternative sources of high-grade graphite will become attractive in order to ensure security of supply, especially in Japan and the United States which will still have to rely on imports for coarse crystalline flake graphite.

PRICES

Representative year-end graphite prices[1], f.o.b., $US per short ton

	1983	1984	1985	1986
Flake and crystalline graphite, bags				
China	54 - 1,542	54 - 1,542	54 - 1,542	66 - 1,874
West Germany	318 - 3,175	286 - 3,084	227 - 3,357	496 - 3,551
Madagascar	227 - 544	227 - 726	227 - 816	353 - 1,213
Norway	181 - 635	181 - 816	- -	- -
Sri Lanka	499 - 1,367	272 - 1,367	272 - 1,361	331 - 1,653
Amorphous, nonflake, microcrystalline graphite (80-85% carbon)				
South Korea (bags)	82 - 109	82 - 109	82 - 113	99 - 132
Mexico (bulk)	64 - 91	64 - 109	82 - 109	99 - 138

"Industrial Minerals"[2] pricing quotation, cif, U.K. port, $US per tonne

	1986
Crystalline lump, 92-99% C	550 - 1,100
Crystalline large flake, 85-90% C	630 - 1,000
Crystalline medium flake, 85-90% C	490 - 860
Crystalline small flake, 80-95% C	300 - 800
Powder (200 mesh), 80-85% C	250 - 275
90-92% C	410 - 460
95-97% C	550 - 750
97-99% C	750 - 1,000
Amorphous powder, 60-85% C	175 - 350

"Chemical Marketing Reporter"[3], f.o.b., bags, $US per pound

	1986
Crystalline, powder, 88-90%	.30 - .60
90-92%	.40 - .70
95-96%	.60 - .90
97% and up	.80 - 1.20
Flake, No. 1, 90-95%	.65 - .75
No. 2, 90-95%	.65 - .75
Amorphous, powder	.16 - .40
powder, 97% and up	.80 - 1.20

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[1] U.S. Bureau of Mines, quoted from Engineering and Mining Journal. [2] IM, November 1986.
[3] CMR, December 1986.
f.o.b. Free on board; cif Cost, insurance and freight.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
CANADA					
31300-1	Plumbago, not ground or otherwise manufactured	free	free	10	free
31400-1	Plumbago, ground, and manufactures of, nop, and foundry facings of all kinds	9.9	9.9	25	6.5
31400-2	Plumbago flakes	4.1	4.1	25	
31405-1	Graphite blocks exceeding forty inches in diameter and fifteen inches in thickness for use in the manufacture of moulds for castings wheels for railway vehicles, including locomotives and tenders	free	5	25	free
31500-1	Carbons or carbon electrodes over three inches in circumference or outside measurement and not exceeding thirty-five inches in circumference or outside measurement; carbons of a class or kind not produced in Canada, when imported for use in the manufacture of dry batteries and dry cells	free	free	free	free
31505-1	Carbons or carbon electrodes exceeding thirty-five inches in circumference or outside measurement	free	15.6	20	free
31600-1	Electric light and arc carbons pointed or not, and contact carbons, nop	12.4	12.4	35	8

MFN Reductions under GATT (effective January 1 of year given)	1986	1987
	(%)	
31400-1	9.9	9.2
31400-2	4.1	4.0
31505-1	15.6	15.0
31600-1	12.4	11.3

		Most Favoured Nation		Non-MFN
		1986	1987	1986
UNITED STATES				
517.21	Crystalline flake (flake dust), valued not over 5.5¢/lb.	3.4% ad val	3% ad val	1.65¢/lb

TARIFFS (cont'd)

Item No.		Most Favoured Nation 1986	Most Favoured Nation 1987	Non-MFN 1986
UNITED STATES (continued)				
517.24	Crystalline flake (not including flake dust), valued over 5.5¢/lb.	0.3¢/lb.	free	1.65¢/lb
517.27	Lump and chip	free	free	30% ad val
517.31	Other	free	free	10% ad val
517.61	Electrodes, in part of carbon or graphite, for electric furnace or electrolytic purposes	2.9% ad val	2.4% ad val	45% ad val
517.71	Carbons and electrodes for producing electric arc light, under 0.5 inch in diameter	3.3% ad val	2.8% ad val	60% ad val
517.74	Carbons and electrodes, for producing electric arc light, 0.5 inch or more in diameter	2.9% ad val	2.4% ad val	45% ad val
517.81	Brushes for electric motor, and other forms for manufacturing brushes	3.9% ad val	3.7% ad val	45% ad val
517.91	Articles of carbon or graphite not specially provided for	5.2% ad val	4.9% ad val	45% ad val

Sources: The Customs Tariff (1986), Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated (1986), USITC Publication 1775.
nop Not otherwise provided for; ad val Ad valorem.

TABLE 1. IMPORTS OF CRUDE GRAPHITE AND GRAPHITE RELATED PRODUCTS INTO CANADA, 1983-86

	1983		1984		1985		1986P	
	tonnes	$000	tonnes	$000	tonnes	$000	tonnes	$000
Graphite, crude								
United States	..	1,505	..	1,788	..	2,098	..	2,681
West Germany	..	30	..	138	..	85	..	131
Norway	..	..	..	..	..	74	..	0
Other countries	..	140	..	4	..	52	..	165
Total	..	1,675	..	1,930	..	2,308	..	2,977
Graphite and carbon brush stock								
United States	69	1,025	61	1,296	133	2,135	32	636
West Germany	1	29	..	0	1	17	0	0
Other countries	2	51	1	6	5	43	0	0
Total	72	1,105	62	1,302	139	2,198	32	636
Graphite electrodes								
United States	1 770	5,316	3 981	10,141	3 157	9,486	3 492	10,845
Japan	1 074	3,233	2 545	6,269	2 160	6,146	1 879	5,911
Other countries	70	212	670	1,702	547	1,338	185	529
Total	2 914	8,761	7 196	18,112	5 884	16,970	5 556	17,285
Carbon or carbon electrodes, nes								
United States	1 408	4,233	7 321	7,538	64 465	44,741	63 714	43,108
Japan	469	1,320	861	2,652	360	1,308	1 569	2,651
Italy	2 517	4,390	2 186	3,566	1 761	3,084	1 546	2,650
United Kingdom	38	89	67	141	7	77	15	130
Other countries	1 146	1,390	2 322	3,147	6 605	4,811	2 409	3,668
Total	5 578	11,422	12 757	17,044	73 198	54,021	69 253	52,207
Graphite and carbon crucibles								
United States	..	522	..	865	..	1,277	..	687
United Kingdom	..	455	..	487	..	10	..	98
France	..	145	..	177	..	70	..	4
Other countries	..	10	..	20	..	17	..	48
Total	..	1,120	..	1,549	..	1,374	..	837
Graphite and carbon refractories, nes								
United States	..	1,414	..	1,579	..	1,211	..	1,533
West Germany	..	438	..	5	..	4	..	1,292
United Kingdom	..	6	..	317	..	123	..	137
Japan	..	44	..	282	..	555	..	0
Other countries	..	0	..	0	..	117	..	83
Total	..	1,902	..	2,953	..	2,010	..	3,045
Graphite and carbon basic products, nes								
United States	..	7,618	..	14,480	..	15,838	..	15,591
Japan	..	457	..	906	..	943	..	222
Other countries	..	1,121	..	1,727	..	7,511	..	2,472
Total	..	9,196	..	17,113	..	24,292	..	18,285

Source: Statistics Canada.
P Preliminary; .. Not available; nes Not elsewhere specified.

TABLE 2. END-USES OF GRAPHITE SUBSTITUTES AND NATURAL GRAPHITE

Product	Manufacturing Goods	Industrial Sector
Activated Carbons (oxidized organic materials)	Absorbants	Automobiles, chemicals
	Decolorizers	Food
	Purifiers	Water treatments
	Solvents	Chemicals
Amorphous carbon (petroleum coke)	Anode, electrode	Alumina, aluminum Calcium carbide Ferrosilicon, ferromanganese and ferrochromium
	Carbon bricks, carbon linings	Alumina smelters Blast furnace
	Crucibles and retorts	Foundry cupolas
	Sealing rings, bushings, washings and wear rings	Pump, turbine, motor nuclear reactors, mechanical engineering
	Carbon arc lighting and flame arc	Light therapy, photo-engraving, irradiation, graphic art
Carbon and graphite fibres (pyrolized organic fibres, pitch)	Reinforcing fibres	Aircraft, aerospace, sporting goods, automobile, textile, medical and musical equipment
Carbon black (soot)	Pigments	Ink, paints, plastics, paper
	Synthetic rubber	Motor vehicle tires
Manufacturing Graphite (baked carbon)	Anode	Chlor-alkalies
	Electrode	Electric arc furnaces (steel)
	Moderators, reflectors and thermally stable components	Aerospace vehicles, nuclear reactors
	Motor brushes	Electrical motors
Natural Graphite (microcrystalline, flake, vein)	Carbon raiser	Steelmaking
	Carbonaceous additives and refractories	Foundries Metallurgy industries
	Pencils	
	Dry batteries cells	Electronic industries
	Lubricants	Mechanical engineering
	Brake linings	Automobile

TABLE 3. GRAPHITE, WORLD PRODUCTION, ALL TYPES, 1981-85[e]

Country	1981	1982	1983	1984[r]	1985[e]	Type of Graphite
			(tonnes)			
China[e]	184 000	184 000	184 000	184 000	185 000	flakes, microcrystalline
U.S.S.R.[e]	70 000	70 000	75 000	80 000	82 000	flakes, microcrystalline
Czechoslovakia[e]	50 000	50 000	50 000	50 000	59 000	microcrystalline
South Korea	34 040	36 330	30 020	56 250	50 000	microcrystalline
(South Korea)	840	630	800	2 300	2 000	flakes
Mexico	41 130	34 360	34 010	40 000	40 000	microcrystalline
(Mexico)	1 150	1 800	1 500	1 500	1 700	flakes
Austria	23 800	24 450	40 420	43 790	40 000	microcrystalline
India	72 790	52 360	35 010	36 000	40 000	flakes, run of mill
Brazil	17 500	15 410	16 500	32 600	32 600	flakes
North Korea[e]	25 400	25 400	25 400	25 400	25 400	microcrystalline
Madagascar	13 330	15 350	13 550	13 550	14 000	flakes
Zimbabwe	11 220	8 220	8 000	12 300	12 000	microcrystalline
West Germany	10 000	10 000	11 800	9 000	10 900	flakes
Sri Lanka	7 570	8 800	8 000	5 600	5 400	crystalline vein
Norway	8 660	7 440	8 060	9 500	2 200	flakes
Others	4 270	22 030	8 280	19 910	11 600	all types
Total	575 700	556 530	550 350	621 700	613 800	

Sources: USBM, Graphite; Harold Taylor, 1985.
[e] Estimated; [r] Revised.

TABLE 4. WORLD, NATURAL GRAPHITE, MAJOR TRADE FOR SELECTED COUNTRIES, 1984-85

Exporting Countries	Importing Countries France	 West Germany	 Japan	 United Kingdom	 United States
			(tonnes)		
1984					
Brazil	102	-	51	-	2 463
China	326	8 575	39 254	5 566	13 815
Germany, W.	226	n.a.	29	-	780
Italy	-	-	-	-	-
Korea, N.	-	-	11 026	-	-
Korea, S.	-	-	30 829	-	-
Madagascar	93	-	972	5 310	2 722
Mexico	-	-	-	-	25 273
Norway	-	1 825	-	5 077	-
Sri Lanka	-	-	1 719	2 000	809
Other	391	17 204	1 129	1 586	6 964
Total	1 138	27 604	85 009	19 539	52 826
1985					
Brazil	136	-	168	-	6 228
China	366	8 370	31 640	9 332	13 074
Germany, W.	227	n.a.	36	282	866
Italy	-	-	-	-	-
Korea, N.	-	-	5 410	-	-
Korea, S.	-	-	38 040	-	-
Madagascar	346	2 525	1 611	6 493	2 710
Mexico	-	-	-	-	19 822
Norway	-	1 190	-	2 490	-
Sri Lanka	280	-	1 499	2 626	1 500
Other	168	22 003	453	322	3 631
Total	1 572	33 998	78 857	23 459	47 831

- No trade reported; n.a. Not applicable

TABLE 5. REPORTED CONSUMPTION OF GRAPHITE IN CANADA, 1977-85

	1977	1978	1979	1980	1981	1982	1983	1984	1985P
					(tonnes)				
Reported consumption[1] of graphite									
Foundry facing	3 060	2 234	2 800	3 078	3 850	1 476	4 309	5 297	5 404
Metallurgical	460	55	505	468	556	2 835	3 710	4 725	4 802
Refractories	667	1 024	477	583	497	10 155	515	761	472
Other[2]	850	839	1 998	1 788	1 669	1 087	1 189	1 884	1 335
Total	5 037	4 152	5 780	5 917	6 572	15 553	9 723^{r}	12 670^{r}	12 013

[1] Reported from EMR survey on the consumption of non-metallic minerals by Canadian manufacturing plants. [2] Includes brake linings, chemicals, abrasives, batteries and other end-uses.

P Preliminary; ^{r} Revised.

Iron Ore

B.W. BOYD

World production, consumption and trade in iron ore was maintained at the same level in 1986 as in 1985. The industry was not stagnant, however, as new projects and expansions were brought on-stream in several countries while mines closed in North America. Trade patterns also shifted as the major importers, Western Europe, United States and Japan experienced a further decline in steel production while other countries achieved significant growth.

The world price of iron ore fell slightly in 1986, as it had each year since 1982. A further problem for the Canadian producers was a trend to sell a larger proportion of their production each year at the world price. The effect in 1986 was an average revenue of $34.76 per tonne, the lowest since 1980, and a decrease of $2.25 per t from last year.

The Canadian iron ore industry made several adjustments in response to a changing market. One Ontario mine closed in 1986 and another cut capacity by half. Productivity increased at the remaining mines due to many improvements, and cost control had priority at all operations. The mines in the Quebec-Labrador region intensified their marketing efforts offshore, successfully signing new contracts in South Korea and Japan.

CANADIAN DEVELOPMENTS

Canadian shipments of iron ore declined 3 million t relative to 1985, and at 36.1 million t, had a value of only $1,255 million. Production was estimated at 36.9 million t, representing 70 per cent of capacity.

Employment at Canadian iron ore mines, concentrators and agglomerating plants was about 6,900 at the end of the year as compared with 7,036 in 1985 and 17,000 eleven years previous.

Exports approached 29 million t, and as in the past several years, western Europe was the largest market for Canadian ore. Exports to the United States were down some 600 000 t due largely to reduced shipments to The LTV Corporation and Wheeling-Pittsburgh Steel Corporation. These two companies have filed, under U.S. law, for Chapter 11 protection from bankruptcy, and stopped taking delivery of their designated shares of iron ore pellets from the Iron Ore Company of Canada and Wabush Mines in 1986.

Iron Ore Company of Canada (IOC) operated at 90 per cent of pellet capacity and 70 per cent of concentrate capacity over the year. A record 1.2 million t of fluxed pellets were produced using local dolomite and imported limestone. The dolomite for the fluxed pellets was mined 7 km from IOC's Carol Lake iron ore mine and exceeded the specifications originally required for the product.

In September, one of IOC's new wet grind circuits went into operation. The second circuit was activated in mid-December. Over the winter months all of the grinding will be in the wet circuits, the dry grind being used only in summer for concentrate production.

IOC announced changes in May that removed Hanna's obligation to purchase a portion of pellet production and made Bethlehem Steel Corporation IOC's largest shareholder (32.84 per cent). Under the new arrangement, each partner will take a smaller quantity of iron ore at Lake Erie prices each year, and be able to take remaining requirements at the prevailing world price.

IOC signed a five year, 1.5 million t contract with Pohang Iron and Steel Co. Ltd. (Posco) of South Korea. This long-

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term sale is a significant new market for IOC in one of the countries with a growing steel industry.

IOC, as well as the other mines in Quebec and Labrador, will be facing labour negotiations when contracts with the United Steelworkers of America expire on February 28, 1987.

Quebec Cartier Mining Company (QCM) operated its pellet plant at near capacity to produce 7.3 million t of pellets during the year. Concentrate production, however, was down marginally and, at 6.8 million t (net of pellets), was at 74 per cent of capacity. The mine and concentrator at Mount Wright were closed from December 9, 1986 to January 2, 1987 but the pellet plant at Port Cartier was operated without a break.

A new deposit, baseline 'B', was opened for production in December and will be in full operation in January 1987. The deposit has over 50 million t of reserves, chiefly as hematite and grading 34 per cent iron (Fe). The Canadian and Quebec governments contributed to road construction near Mount Wright, which provided access to the new deposit.

QCM entered the Japanese market with a 170 000 t test shipment to Nippon Steel Corp. and Nisshin Steel Co. Ltd. late in the year.

Wabush Mines was hit hard by bankruptcy avoidance measures taken by The LTV Corporation and Wheeling-Pittsburgh Steel Corporation, which together own 25.8 per cent of the Wabush operation. Production for the year fell to 4.9 million t, representing 80 per cent of capacity. In an effort to maintain sales, Wabush took action to reduce the manganese (Mn) content of its pellets which, at 2 per cent, has hindered their marketability to some steel plants. Tests to extract the manganese from concentrate using a leach, crystallization and roast process were successfully completed in September. The manganese oxide produced by the process was being tested for reducibility to manganese metal by plasma burners at Hibbing, Minnesota. An engineering study for a commercial plant was undertaken at the end of 1986, and financing of the project will likely be investigated during 1987. In the meantime, Wabush arranged to take delivery of 28 000 t of concentrate with an Mn content of 0.03 per cent from QCM. Wabush will run tests on a blend of its own concentrate and the QCM material for the production of pellets with intermediate Mn content.

In November, Cleveland-Cliff Inc. (Cliffs) announced its intention to acquire Pickands Mather & Co. (P-M), the manager of Wabush Mines and owner of 5.2 per cent of the shares. The transaction is expected to involve a trade of Cliffs oil and gas reserves, mainly in the western United States for P-M's interests in two iron ore mines in the United States, Wabush Mines in Canada, Savage River Mines in Australia, five coal mines and P-M's research facility at Hibbing. Cliffs also manages Dofasco Inc.'s iron ore mines in Ontario.

The Algoma Ore Division of The Algoma Steel Corporation, Limited, laid off 138 hourly workers and 30 staff at the iron ore mine and sinter plant in Wawa, Ontario as part of a major restructuring of the whole operation. The operating rate of the mine was reduced from about 3 million tpy of ore to 1.4 million t, from which superfluxed sinter was produced at the rate of 900 000 tpy for shipment to Sault Ste. Marie. The lower tonnage of sinter from Wawa was blended with acid pellets from Michigan to provide a suitable blast furnace feed for Algoma's steel mill.

Dofasco Inc.'s two iron ore mines in northern Ontario, the Adams and Sherman operated for nine months in 1986 and produced close to 1 million t of pellets each. Dofasco invested $1.5 million in the operations to prepare fluxed pellets containing limestone and dolomite from Ontario quarries. Dofasco is now almost totally committed to fluxed pellets from its own mines and IOC, with very successful results on material savings and higher efficiency in the blast furnaces.

A rock fall at the Adams mine did not seriously affect production.

The Griffith mine located near Ear Falls, Ontario closed permanently at the end of March 1986. Pellet production was terminated at the end of February and heavy media production one month later. The employees still on-site at the time of closure were engaged in removing equipment and rehabilitating the mine site. Stelco Inc. which owned the mine, sourced additional ore from Labrador Trough mines to replace production from Griffiths.

WORLD DEVELOPMENTS

The steel industry in the United States retrenched further in 1986. LTV Corp., the third largest U.S. steel company, filed for Chapter 11 protection from bankruptcy in July 1986 and Wheeling-Pittsburgh continued to receive this protection throughout the year. On August 1, 1986, USX Corporation, the largest U.S. steelmaker, locked out workers for not accepting its terms for a new contract. The lock-out was still in effect at year-end.

Reserve Mining Co. in which The LTV Corporation has a 50 per cent interest, filed under Chapter 11 of the bankruptcy act and closed in July. Cleveland-Cliff Inc. sold its share of the Robe River mine in Australia to raise cash that was needed because of the worsening situation in the United States iron ore industry.

By the end of September 1986, deliveries of iron ore to U.S. steel plants were down 7.5 million t, 16.6 per cent from the same nine-month period a year earlier.

Imports of iron ore were also down in 1986 and pressure to cut imports further continued throughout the year.

An investigation of imported iron ore pellets from Brazil had been initiated in early-1985. On June 17, 1986 the International Trade Administration (ITA) of the United States Department of Commerce published a countervailing duty determination against Companhia Vale do Rio Doce (CVRD) of Brazil for iron ore pellets. The estimated subsidy for the review period, calendar 1984, was 2.09 per cent ad valorem. Due to changes in sales since then, the ITA required a 7.94 per cent cash deposit or bond for deliveries after the publication date.

However, the United States International Trade Commission determined there was no injury or threat of injury from the importation of Brazilian iron ore pellets. This decision closed the one and a half year case. On the other hand, the case set a precedent, inasmuch as the investigation was the first one to be directed at an ore concentrate rather than a further processed product.

Companhia Vale do Rio Doce (CVRD) began production from the Carajas mine in January. Production for the first year was 12 million t and is scheduled to rise to 22 million t in 1987. The planned capacity for the project is 35 million tpy, but the company has said it will postpone increasing production to that level until the end of the current market softness.

Mineracoes Brasileira Reunidas SA (MBR) arranged financing for major developments in the Minas Gerais province to open mines and improve railways. MBR exported close to 15 million t of iron ore in 1986 and planned to increase exports to 25 million tpy in the next few years.

M.A. Hanna Company of the United States sold its 34.27 per cent interest in MBR in late-1986. This was the only remaining major U.S. ownership in Brazilian iron ore mining.

Two of the world's largest ore/oil carriers were delivered in November to transport iron ore from Brazil to Japan. The 305 000 dwt carriers will take oil from the Middle East to Brazil as a back-haul.

Brazil again was the second largest iron ore producer in the world, after the Union of Soviet Socialist Republics, and was the world's largest exporter, surpassing Australia for the third year in a row.

In Australia, the current soft market precluded the development of new large-scale projects. However, deposits adjacent to existing mines and requiring little new infrastructure may be developed in the near-term. Examples of possible projects are the Channar deposit, near Paraburdoo which is being considered for joint venture development with the Chinese Metallurgical Import and Export Corporation, and the Marandoo deposit which could be linked to existing facilities of Hamersley Iron Pty., Ltd.

Robe River Iron Associates suffered its second strike in the year when about 900 workers left their jobs at the Pannawonico mine and the port at Cape Lambert on December 17. The strike was a protest over the use of non-union staff to drive ore trains, but is symptomatic of problems Peko-Wallsend Ltd. has had in trying to eliminate restrictive work practices that have developed over past years.

Japan, China, Federal Republic of Germany and Republic of Korea were the largest export markets for Australian iron ore.

The steel industry in China was undergoing significant expansion and provided a promising market for internationally traded iron ore, especially from Australia.

New mine developments completed in 1985 and 1986 brought India's iron ore production capacity to 70 million tpy. Exports in 1986 were 28 million t and Indian producers were planning to increase exports to 30 million t in 1987. It now appears likely that India will replace Canada as the third largest exporter of iron ore in 1987 or 1988. India's chief markets are Japan, South Korea and Romania, but Indian exporters intend to expand into the western European market.

PRICES

Western Europe and Japan each take about a third of the iron ore traded internationally. Their annual price negotiations with the many exporters, including Canadian companies, normally take place in November and December for shipments to Europe on a calendar year basis, and in January to March for shipments to Japan on a fiscal year basis.

Iron Ore Company of Canada (IOC) and Quebec Cartier Mining Company (QCM) were the first exporters to settle 1986 sales contracts with buyers in the Federal Republic of Germany. The Canadians accepted a 1.1 per cent reduction in the price for concentrate, f.o.b. St. Lawrence port, and no change in the pellet price.[1]

Other exporters settled shortly thereafter and apparently accepted the buyer's system of standardizing prices on the basis of arrival at Rotterdam. This brought price reductions as high as 5.9 per cent for some Australian lump ore. In general, the price gap between lump ore and concentrate or fines, and the premium for pellets were all reduced.

The Indian trading company Minerals & Metals Trading Corp. of India Ltd. (MMTC) settled its contracts with Japanese buyers early and, with price reductions averaging 4.92 per cent, was able to increase shipments by 1.5 million t during fiscal year 1986.

South Africa and Chile took even larger price cuts on shipments to Japan (7.54 per cent and 12 per cent respectively) compared to Canada and Australia which took a reduction of 4 per cent.

The expectation that Japan will be reducing iron ore imports by over 7 million t in 1987 will leave little room for Canadian negotiations on either price or quantity.

UNCTAD DIALOGUE ON IRON ORE

An Intergovernmental Group of Experts on Iron Ore (IGE) met in Geneva on October 27-31 under the auspices of the United Nations Conference on Trade and Development (UNCTAD). Thirty-four countries, including industry experts from twenty companies, and four intergovernmental agencies (United Nations International Development Organization, Organization for Economic Cooperation and Development, Commission of the European Community, Association of Iron Ore Exporting Countries) were represented.

Progress was achieved on a new questionnaire that will be used to improve statistics on the iron ore industry and market transparency. Market developments and outlook, structural and technological change and other items which directly affect iron ore trade were subjects of reports made available at the meeting and formed the basis of constructive discussions. A full agenda was prepared for the next IGE, tentatively scheduled for October 1987.

DIRECT REDUCTION

Sidbec operated the larger of its two Midrex modules at close to capacity of 1 million t in 1986. The company invested in eccentric bottom tapping on two of its electric furnaces and in facilities for ladle refining of steel during the year.

By the end of 1985, 49 direct reduction plants had been constructed in the world. Production reached 21.62 million t of iron in that year.

In 1986, capacity at the Stary Oskol works, near Kursk, U.S.S.R., doubled to 834 000 tpy and planned additional modules would make the plant, at 4.8 million tpy, the largest DRI facility in the world. On November 26, 1986, Egypt put into production its first DRI module of 716 000 tpy capacity at El Dikheila, adjacent to a new integrated steelworks.

OUTLOOK

The ongoing restructuring taking place in the steel industry, particularly the retrenchment under way in the United States, continued to have a major impact on the strategies and perspectives of Canadian iron ore producers. A major concern in 1986 was reduced orders for iron ore from owners of Canadian mines. In response to this change, the Iron Ore Company of Canada was reorganized to lower the cost of iron ore to its owners and to facilitate offshore sales. For example, the agreement no longer guarantees as large a supply of iron ore to the owners, and gives marketing agent M.A. Hanna Company much more freedom to sell to third parties, to sell at world price and to offer guarantees for long-term delivery to third party customers.

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[1] Price is reported in cents, United States currency, for each percentage point of iron in a t of ore; e.g. at 30¢/Fe unit, ore grading 65 per cent iron would bear a price of 65 x 30¢ = $US 19.50/t.

Canadian iron ore producers in recent years have cooperated closely with consumers to develop more sophisticated products tailored to specific user needs. Self-fluxed pellets for Dofasco Inc. and Bethlehem Steel Corporation is an example of this trend and all the exporting companies have plans to improve their product lines.

Production of iron ore in Canada is forecast to remain in the 35 to 45 million tpy range for the medium-term. The proportion of acid pellets, self-fluxed pellets, pellets with specific manganese and silica content, and products not yet available will no doubt increase relative to concentrate sales. Employment in the industry is not likely to increase but the 50 per cent drop experienced in the past 10 years will not be repeated unless the price of iron ore plummets further due to as yet unforeseen factors.

The delay in reaching full capacity at Carajas, announced by CVRD, could result in firmer prices for 1987 and 1988. The impact of Carajas prices may already be accounted for in the world market. Given time, the growth of steel plants in Brazil and other developing countries will provide for more price recovery.

Since 1737, when Cugnet & Cie began iron ore mining on the St. Maurice River, iron ore mining has had many triumphs and disappointments in Canada. In this, the hundredth anniversary edition of the Canadian Minerals Yearbook, the immediate preoccupation is short-term survival for the Canadian iron ore industry but, at the same time, a base is being developed for long-term recovery.

TABLE 1. CANADA, IRON ORE PRODUCTION AND TRADE, 1985 AND 1986

	1985		1986P	
	(tonnes)[1]	($000)	(tonnes)[1]	($000)
Production (mine shipments)				
Newfoundland	20 192 123	774,002	19 865 864	782,683
Quebec	14 875 996	C	13 200 000	C
Ontario	4 346 511	C	3 366 807	C
British Columbia	87 571	3,830	63 780	3,482
Total[2]	39 501 601	1,462,254	36 095 071	1,254,798
Imports			(Jan.-Sept.)	
Iron ore				
United States	5 133 251	327,552	2 959 672	176,614
Brazil	666 903	21,503	452 842	14,865
Japan	-	-	5 000	107
Italy	37	3	51	4
Total	5 800 191	349,058	3 417 565	191,590
Exports				
Iron ore, direct shipping				
Italy	0	0	106 790	1,987
United States	504 289	9,879	78 500	1,190
United Kingdom	246 549	6,694	69 329	1,317
Total	750 838	16,573	254 619	4,494
Iron ore, concentrated				
West Germany	2 470 286	55,672	1 758 531	40,519
Netherlands	2 656 657	61,591	1 066 063	34,328
France	1 451 006	30,155	1 471 509	33,397
United Kingdom	1 180 637	25,106	1 113 130	24,057
Japan	3 198 419	67,171	1 199 173	24,050
United States	1 520 833	33,349	569 388	11,740
Italy	606 214	15,409	498 076	10,326
Belgium-Luxembourg	232 363	5,429	252 618	5,803
Philippines	208 909	4,325	221 059	4,642
Pakistan	241 804	5,074	192 981	4,091
Portugal	64 000	1,523	131 541	3,291
Austria	211 331	4,361	183 994	2,975
Yugoslavia	475 980	16,287	75 347	2,491
Spain	53 099	1,259	57 121	1,347
South Korea	137 133	2,779	0	0
Total	14 708 711	329,490	9 649 851	203,057
Iron ore, agglomerated				
United States	6 974 103	407,684	5 671 402	335,967
United Kingdom	3 945 557	162,509	2 505 387	83,382
Netherlands	2 173 875	108,085	1 264 825	41,936
Italy	792 938	37,680	757 917	35,591
West Germany	1 215 744	53,392	982 913	31,763
Belgium-Luxembourg	435 238	19,626	495 637	19,613
France	573 335	20,859	283 718	8,861
Yugoslavia	222 634	6,831	151 277	5,202
Portugal	142 354	5,099	156 460	5,133
Austria	50 898	1,648	102 631	3,334
Panama	64 950	4,417	-	-
Total	16 591 706	827,830	12 432 167	570,782
Iron ore nes, including by-products				
United States	134 987	2,234	12 586	209
Total	134 987	2,234	12 586	209
Total exports, all classes				
United States	9 134 292	453,146	6 331 796	349,307
United Kingdom	5 372 743	194,309	3 687 846	108,756
Netherlands	4 830 532	169,676	2 330 888	76,264
West Germany	3 686 030	109,064	2 741 444	72,282
Italy	1 399 152	53,089	1 362 783	47,903
France	2 024 341	51,014	1 755 227	42,258
Belgium-Luxembourg	667 601	25,055	748 255	25,416
Japan	3 198 419	67,171	1 199 173	24,050
Portugal	206 354	6,622	288 001	8,424
Yugoslavia	698 614	23,118	226 624	7,693
Austria	262 229	6,009	286 625	6,309
Philippines	208 909	4,325	221 059	4,642
Pakistan	241 804	5,074	192 981	4,091
Spain	53 099	1,259	57 121	1,347
Other countries	202 083	7,196	-	-
Total	32 266 242	1,174,127	21 709 183	778,742
Consumption of iron ore at Canadian iron and steel plants	15 088 767	..	10 689 617	..

Sources: Energy, Mines and Resources Canada; Statistics Canada; American Iron Ore Association.

[1] Dry tonnes for production (shipments) by province; wet tonnes for imports and exports.

[2] Total iron ore shipments include shipments of byproduct iron ore.

P Preliminary; C Withheld to avoid disclosing company proprietary data; - Nil; .. Not available; nes Not elsewhere specified.

TABLE 2. CANADA, IRON ORE PRODUCTION (SHIPMENTS), 1983-86

Company and Location	Ore Mined	Product Shipped	1983	1984	1985	1986P
			(000 tonnes, natural or wet)			
Adams mine, Kirkland Lake, Ont.	Magnetite	Pellets	865	1 105	1 141	1 000
Algoma Ore division of The Algoma Steel Corporation, Limited Wawa, Ont.	Siderite	Sinter	1 247	1 280	1 382	1 300
Griffith mine, Bruce Lake, Ont.	Magnetite	Pellets	790	954	789	100
Iron Ore Company of Canada Schefferville, Que.	Hematite, goethite and limonite	Direct shipping	1 366	1 525[1,2]	1 830[1,2]	600[1,2]
Carol Lake, Lab.	Specular hematite and magnetite	Concentrate	5 618	5 753	4 997	4 800
		Pellets	6 990	7 956	8 168	9 565
Sept Îles, Que.	Schefferville "treat ore"	Pellets	235[2]	303[2]	-	-
Quebec Cartier Mining Company, Mount Wright, Que.	Specular hematite	Concentrate	6 683	9 898	8 619	6 800
		Pellets	-	-	6 638	7 300
Normines Inc. Fire Lake, Lac Jeannine, and Port Cartier, Que.	Specular hematite	Concentrate	-	-	-	-
		Pellets	3 706	4 883	-	-
Sherman mine, Temagami, Ont.	Magnetite	Acid Pellets	760	1 015	474	-
		Fluxed Pellets	-	-	524	1 000
Wabush Mines, Wabush, Labrador and Pointe Noire, Que.	Specular hematite and magnetite	Pellets	5 180	6 319	5 696	4 800
British Columbia Producers	Magnetite	Pellet feed, Magnetite concentrate	492	155[2]	87[2]	64[2]
Other Ontario	Pyrrhotite, magnetite	Pellets, Magnetite concentrate	-	187	140	-
			33 532	41 333	40 485	37 329

[1] Includes some Carol Lake concentrate. [2] Stockpile ore.
P Preliminary; - Nil.

TABLE 3. RECEIPTS AND CONSUMPTION OF IRON ORE AT CANADIAN IRON AND STEEL PLANTS, AND INVENTORIES, 1985 AND 1986

	1985	Jan.-Oct. 1986
	(000 tonnes)	
Receipts imported	5 815	4 375
Receipts from domestic sources	8 594	7 173
Total receipts at iron and steel plants	14 409	11 549
Consumption of iron ore	15 008	11 659
Inventory at docks, plants, mines and furnace yards, December 31	11 179	11 018
Inventory change	964	-161

Source: American Iron Ore Association.

TABLE 4. WORLD IRON ORE PRODUCTION, 1983-85

	1983	1984	1985e
	(000 tonnes)		
U.S.S.R.	245 200	247 100	247 640
Brazil	92 100	112 100	120 000
Australia	73 170	91 640	95 270
People's Republic of Chinae	113 660	121 900	130 000
India	37 580	40 760	42 550
United States	38 560	52 100	48 849
Canada	33 532	41 333	40 485
Republic of South Africa	16 600	24 650	24 390
France	15 970	15 030	14 480
Liberia	15 410	16 100	16 120
Sweden	13 530	18 120	20 270
Venezuela	9 450	13 060	14 760
Other countries	77 078	81 057	82 396
Total	781 840	874 950	897 210

Source: Association of Iron Ore Exporting Countries (APEF).
e Estimated.

TABLE 5. CANADIAN CONSUMPTION OF IRON-BEARING MATERIALS BY INTEGRATED[1] IRON AND STEEL PRODUCERS, 1985

	Consumed In				
			Iron and Steel Furnaces		
Material Consumed	Sinter Plants at Steel Mill	Direct Reduction Plants	Production of Pig Iron	Steel Furnaces	Total in Furnaces
			(tonnes)		
Iron Ore					
Crude and concentrate	225 498	218 632	14 568	-	14 568
Pellets	54 993	862 000	11 949 694	25 968	11 975 662
Sinter	121 880	-	1 267 150	-	1 267 150
Sinter produced at steel plant	-	-	708 232	-	708 232
Direct reduced iron	-	-	-	768 845	768 845
Other iron-bearing materials including flue dust, mill scale, cinder, slag, etc.	280 428	-	271 190	9 839	281 029
Total	682 799	1 080 632	14 210 834	804 652	15 015 486

Source: Company data.

[1] Dofasco Inc.; Sidbec-Dosco Inc.; Sydney Steel Corporation; The Algoma Steel Corporation, Limited; Stelco Inc.

- Nil.

TABLE 6. NORTH AMERICAN PRICES OF SELECTED ORES AT YEAR-END, 1975 AND 1980-86

	1975	1980	1981	1982	1983	1984	1985	1986
					($US)			
Mesabi Non-Bessemer[1]	18.21	28.05	32.02	31.73-32.01	32.25-32.53	30.03-31.53	30.03-31.53	30.03-31.53
Old Range Non-Bessemer and Manganiferous[1]	18.45	28.30	32.26	32.26	32.78	32.78	32.78	32.78
PELLETS: (per gross ton iron unit)[2]								
Lake Erie Base Price[3]	0.464	0.725	0.792	0.792-0.855	0.805-0.869	0.805-0.869	0.869	0.869
USX Corporation[4]	-	-	-	-	-	-	0.725	0.725
Upper Lakes[5]	-	-	-	-	-	-	0.594	0.594
Wabush[6]	-	0.635	0.635	0.635	0.635	0.635	0.635	0.635
Mineral Services Inc.[4]	-	-	-	-	-	0.660	0.580	0.580
Direct Reduced Iron[7]	-	-	-	-	115-135	115-135	115-135	115-135

Sources: Skillings Mining Review; Iron Age.

[1] $US per gross ton, 51.5 per cent of iron natural, at rail of vessel, lower lake ports. [2] $US per gross ton natural iron unit. One iron unit equals 1 percentage point of iron content in a ton of ore; an ore containing 60 per cent iron, therefore, has 60 iron units. [3] Cleveland-Cliff Inc., M.A. Hanna Company, Oglebay Norton Co. at rail of vessel lower lake port. [4] At rail of vessel lower lake port. [5] Pickands Mather & Co. and Inland Steel Mining Co. in hold of vessel upper lake port. [6] F.o.b. Pointe Noire. [7] $US per tonne.
- Nil.

TABLE 7. SELECTED PRICES OF IRON ORE BOUND FOR JAPAN AND EUROPE 1980-86

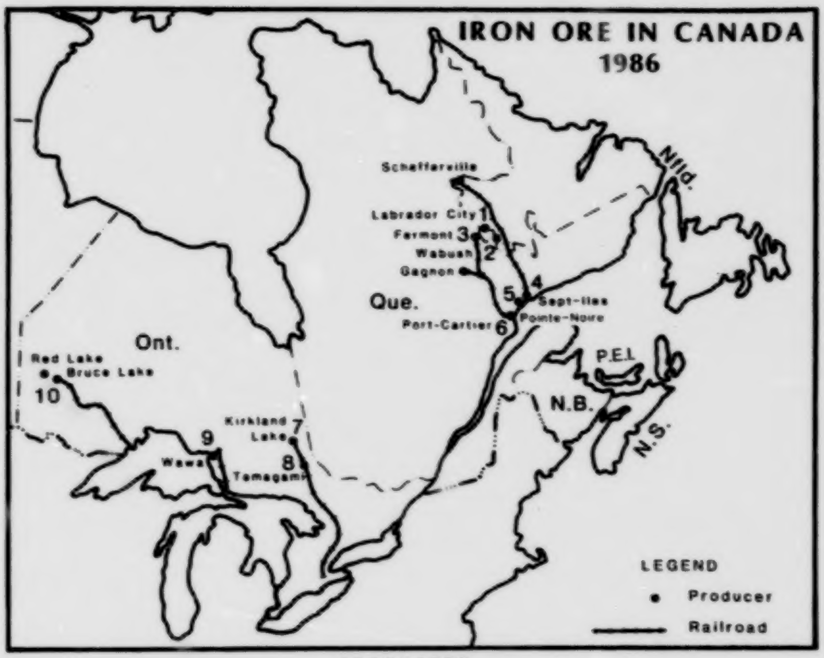
Ore	Market	Source	1980	1981	1982	1983	1984	1985	1986
				(U.S. cents per Fe Unit Dmt, F.o.b.)					
Fines (including concentrate)	Europe	CVRD	28.1	28.1	32.5	29.0	26.15	26.56	26.26
		Iscor	26.9	26.9	31.4	27.9	20.6	23.5	22.7
		Kiruna	34.5	33.0	34.7	30.1	27.7	28.5	27.9
		Carol Lake	29.3	29.3	33.0	29.3	26.8	26.8	26.5
		Mt. Wright	29.75	29.75	33.0	29.3	26.8	26.8	26.5
	Japan	CVRD	25.4	26.9	30.5	27.5	24.27	24.65	23.66
		Iscor	25.0	26.9	30.5	27.0	23.89	22.26	20.55
		Hamersley	27.6	29.7	34.2	30.5	26.67	27.05	25.97
		Carol Lake	25.1	27.0	29.8	26.7	23.37	23.37	22.44
Lump	Europe	CVRD	31.2	31.2	-	-	-	-	-
		Iscor	31.9	31.9	35.9	31.3	24.0	29.0	26.7
	Japan	CVRD	25.4	26.9	30.5	27.9	24.27	24.65	23.66
		Iscor	28.6	30.9	35.0	30.6	27.19	25.86	23.91
		Hamersley	31.2	34.2	40.0	34.9	30.87	31.55	30.29
Pellets	Europe	CVRD	47.1	43.1	47.5	39.0	36.0	36.0	-
		Kiruna	49.9	48.5	50.2	41.0	38.6	38.6	38.15
		Carol Lake & Pt. Cartier	-	-	-	-	-	36.5	36.5
	Japan	CVRD (Nibrasco)	50.3	55.2	53.6	42.9	37.31	36.25	35.29
		Savage River	46.2	48.9	53.4	-	38.3	37.1	36.02

Sources: The Tex Report, Metal Bulletin and Japan Commerce Daily.
- Not available; Dmt dry metric tonne; F.o.b. free on board.

TABLE 8. CAPACITY AND PRODUCTION OF DIRECT REDUCED IRON (DRI), 1985

Country	Capacity (million tpy)	Production (million t)
Argentina	0.93	0.99
Brazil	0.32	0.29
Burma	0.04	0.03
Canada	1.00	0.74
India	0.21	0.09
Indonesia	2.30	1.00
Iran	0.33	0.03
Iraq	0.49	0.00
Malaysia	1.25	0.52
Mexico	2.03	1.46
New Zealand	0.17	0.17
Nigeria	1.02	0.22
Peru	0.10	0.05
Quatar	0.40	0.49
South Africa	1.11	0.41
Saudi Arabia	0.80	0.99
Sweden	0.07	0.00
Trinidad	0.84	0.22
United Kingdom	0.80	0.00
United States	0.40	0.14
U.S.S.R.	0.83	0.42
Venezuela	4.50	2.64
West Germany	1.28	0.10^{e}
Total	21.62	11.00

Source: Midrex Corp., North Carolina, United States.
^{e} Estimated.


IRON ORE IN CANADA
1986
Schefferville
Labrador City 1
Fermont 3
Wabush 2
Gagnon
4
5
Sept-Iles
Pointe-Noire
Port-Cartier 6
Que.
Nfld.
Ont.
Red Lake
Bruce Lake
10
Kirkland Lake 7
9
Wawa
8
Temagami
P.E.I.
N.B.
N.S.
LEGEND
● Producer
Railroad

PRODUCERS

(numbers refer to numbers on map above)

1. IRON ORE COMPANY OF CANADA, CAROL DIVISION (mine/ concentrator/ pellet plant)
2. WABUSH MINES (mine/ concentrator)
3. QUEBEC CARTIER MINING COMPANY (mine/ concentrator)
4. IRON ORE COMPANY OF CANADA (port)
5. WABUSH MINES (pellet plant/ port)
6. QUEBEC CARTIER MINING COMPANY (pellet plant/ port)
7. ADAMS MINE OF DOFASCO INC. (mine/ concentrator/ pellet plant)
8. SHERMAN MINE OF DOFASCO INC. (mine/ concentrator/ pellet plant)
9. ALGOMA ORE DIVISION OF THE ALGOMA STEEL CORPORATION, LIMITED (mine/ concentrator/ sinter plant)
10. GRIFFITH MINE OF STELCO INC. (mine/ concentrator/ pellet plant)

Iron and Steel

R. McINNIS

Steel production in the western world continued to decline in 1986 while in the less developed countries it expanded further partially offsetting the decline elsewhere. Western world steel production as calculated by the International Iron and Steel Institute (IISI) totalled 353.0 million t for 1986 down 5.7 per cent from 1985. Total world production of 714.2 million t declined 0.7 per cent from the 719.1 million t produced in 1985.

In Canada, crude steel production declined 4.0 per cent to 13.3 million t compared to the 13.9 million t produced in 1985. Domestic shipments of rolled steel products and semis decreased marginally to 11.74 million t from 11.76 million t in 1985. The operating rate of Canadian mills averaged 66.3 per cent of their annual capacity which totalled 20.05 million t in 1986.

In the United States production declined by 7.3 per cent to 78.2 million t compared to the 84.4 million t in 1985. Employment levels continued to drop due to work stoppages and to continued rationalization in the industry.

Japan's steel industry experienced a drop in production of about 10 per cent in 1986 from the previous year. This decline was attributed primarily to the appreciation of the yen, especially relative to the U.S. dollar, compounded by a shift in the Japanese economy away from steel-intensive industries. EC steelmakers saw production fall by 7.3 per cent to 12.6 million t.

CANADIAN DEVELOPMENT

Trade continued to be a major issue in 1986. In response to the concerns of the Canadian steel industry, Canada announced that effective September 1, 1986, carbon steel products would be placed on the Import Control List for a period of three years for the purpose of collecting information with respect to the importation of such goods. This action did not limit the quantity of carbon steel products that may be imported into Canada.

A number of investigations for dumping were initiated during the year. A subsequent finding of injury by the Canadian Import Tribunal resulted in the imposition of antidumping duties on oil well casing (Grades H, J, K & 5K) from Argentina, West Germany, Korea and the United States. The Algoma Steel Corporation, Limited later filed a complaint on higher grades and, as the investigation progressed, Japan agreed to an undertaking to price its products, not below specific minimum prices. Japan was the country of origin for 95 per cent of the imports of casing of these higher grades. The investigation was suspended as a result of the undertaking.

Other trade related developments included the formation on August 13, 1986 of the Canadian Steel Producers Association. The membership in this association included 13 companies who melt and pour steel and who account for over 90 per cent of Canadian steel production. The purpose of the association is to effectively communicate to government and the public the position of the Canadian steel industry on steel trade and related matters.

The Canadian Steel Trade Conference Ltd. met for the second time in May. Representatives from management and labour discussed the problems of the steel industry, particularly international competition, trade restraints, and the problems of the work force as the industry adjusted.

Bilateral steel trade with the United States was a primary concern. The U.S. steel industry intensified its lobby with the U.S. administration for protection from imported steel, and made a number of requests to negotiate a voluntary restraint agreement with Canada.

Capital Expenditure Intentions[1] at Canadian iron and steel mills in 1986 were $661 million, up significantly compared to the

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[1] Intentions is a statistic published by Statistics Canada.

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actual expenditures of $424 million in 1985 and $190 million in 1984. Most of the expenditure programs started in the last few years were nearing completion so that capital expenditures will probably decrease in 1987.

INTEGRATED STEEL COMPANIES

The Algoma Steel Corporation Limited

Markets for the company's products, sheet and plates were good while markets for structurals, tubular products and rails remained weak. Lack of orders caused the No. 1 tube mill to be shut for the third quarter and part of the fourth. The No. 2 seamless tube mill is nearing completion with market production scheduled for early-1987.

The recently modernized rail mill commenced operations and the improved rails helped the company increase its share of the domestic market as well as capture new export sales.

Construction was deferred on the addition of ladle metallurgy in the No. 1 steelmaking shop, the conversion of the bloom casters to produce cast rounds in addition to blooms, and the installation of equipment to produce head-hardened rails.

In view of depressed markets for many of the corporations products, and the losses that occurred, Algoma implemented a program of action which is designed to downsize raw steel capacity, move to 100 per cent continuous cast steel, improve product quality and reduce costs. On August 11, 1986, the corporation announced the sale of its 34 per cent interest in AMCA International Limited. The proceeds, approximately $193 million, will be used to reduce the debt and to fund capital expenditures.

The company opened its books to consultants retained by the United Steelmakers of America to validate information provided to union officials.

Dofasco Inc.

Capital expenditure during 1986 of approximately $250 million were related almost entirely to the "Cast Slab Program" which was progressing on schedule towards a completion date of late-1987. This program will result in the installation of the latest technology in ladle metallurgy, slab casting and continuous reheat furnaces. The program also includes two additional finishing stands in the No. 2 Hot Strip Mill. Future capital expenditures have been approved: $56 million for modification of all the company's galvanized and Galvalume steel facilities, and $46 million for extended runout tables and coiler equipment at No. 2 Hot Strip Mill.

In July, the company's largest blast furnace was shut down for a major rebuild. Shipments were maintained from inventories of semi-finished steel which were built up in anticipation of the repair.

Steelmaking production declined in the last half of the year due to factors that included depressed markets for the products of two subsidiary companies, National Steel Car Limited and Prudential Steel Ltd., and a general levelling of demand for flat rolled products.

Stelco Inc.

The company's modernization program, including the rebuild of the No. 1 Bar Mill completed in September, was on schedule. Construction of two new continuous casters at Hilton was near completion. They will be in operation in 1987.

On September 30, 1986 Stelco Inc. and Armco Canada Ltd. jointly announced the inauguration of their new joint venture, Moly-Cop Canada. This facility, which cost $11.5 million, is located in Kamloops, British Columbia. It will manufacture high quality forged heat treated grinding balls.

In March, Stelco Inc. announced that rock bolt production facilities at Notre Dame Works in Montreal would be closed.

Sydney Steel Corporation (Sysco)

Basic engineering for Stage II of the modernization program was contracted to a consortium composed of The SNC Group and Dravo of Canada Ltd., with completion scheduled for March/April 1987.

Stage II includes the installation of an electric arc furnace, a ladle metallurgy station, equipment for head hardening rails and the refurbishing of the existing continuous casting machinery.

Export sales of rails reached a record level of over 100 000 t. The previous high was 96 000 t in 1975. In the domestic market the total quantity of rails sold was low relative to previous years and prices were depressed.

Sysco commissioned Arthur D. Little Inc. to conduct a study on the market for rails.

ELECTRIC FURNACE STEEL COMPANIES

Atlas Steels

Rio Algom Limited, parent company of Atlas Steels, announced that it had completed an agreement for the acquisition of AL Tech Specialty Steel Corporation, Dunkirk, New York, from GATX Corporation, Chicago, Illinois, effective July 1, 1986. AL Tech is the second largest United States producer of bars, rods, wire, pipe, tubing and extruded shapes made from specialty steel. It has manufacturing facilities in Dunkirk and Watervliet, New York. Total 1985 revenues were $US 127 million. This acquisition should result in an increase in the amount of specialty steel produced at Atlas' Welland plant.

The major capital expenditures committed in 1986 was for continuous casting machinery at Welland, Ontario.

Co-Steel Inc.

On December 27, 1985, Lake Ontario Steel Company Limited (LASCO) and 635100 Ontario Limited were amalgamated under the name Co-Steel International Limited. On May 5, 1986 the company's board of directors approved a change in its name to Co-Steel Inc.

A number of capital projects were completed at Co-Steel's subsidiary companies. Among these Lake Ontario Steel Company commissioned its new ladle arc refining facility and started to produce ultra clean steels as well as steels with special properties. This facility is an important factor in the company plan to broaden its market. A speed control system was fitted to the bar mill drives of its mill at Sheerness, Scotland and contributed to a significant increase in mill productivity and product quality.

The product range at Raritan River Steel Company and Chaparral Steel Company - both in the United States was increased.

Courtice Steel Limited

Courtice Steel Limited was acquired by Harris Steel Group Inc. early in 1986. Subsequently, the company announced their plans to invest $35 million in a bar rolling mill adjacent to the Courtice Steel meltshop.

IPSCO Inc.

Sales of tubular products were down substantially from the previous year because falling oil prices forced large cutbacks in exploration and development. However, IPSCO Inc. managed to maintain good sales of flat rolled products in Eastern Canada and the United States.

Steel ingot production costs were substantially lower than in 1985, reflecting lower raw material cost and lower conversion costs.

IPSCO's reheat furnace and slab caster project at Regina, Saskatchewan remained on schedule and within budget. Initial trials were scheduled for February 1987. The caster will increase IPSCO's ability to compete in the flat rolled steel market. In March, a continuous edge milling machine was installed at Calgary Works; it is expected to improve product yields and quality.

Ivaco Inc.

Ivaco Inc. acquired 95 per cent of the common shares of Canron Inc. in 1986. Canron operates within four industries: iron, concrete and plastic pipes; steel fabrication and service; machinery and equipment for industrial and railroad use; and iron foundry products. By year-end, ownership of Canron was reduced to 79 per cent by a secondary offering of Canron shares.

Wholly-owned Florida Wire and Cable Company joined United States and Italian partners in the ownership of Amercord Inc. of Lumber City, Georgia. Amercord is a large U.S. producer of steel tire cord and tire bead wire.

A number of major expansion and modernization projects were completed or under way during the year. At L'Orignal, Ontario, Ivaco Rolling Mills was on schedule with a major upgrading and speed up of its rod mill. This will provide new capacity to work larger and heavier billets. At Laclede Steel Company in Alton, Illinois, (51 per cent owned) work was completed on the expansion and upgrading of the plant to about 50 per cent continuous cast. During the year, programs were under way in practically all of the company's wire producing plants.

Ivaco committed capital expenditures of about $US 20 million for its U.S. operations and $50 million for its Canadian plants in 1986.

Ivaco has become one of the top 12 steelmakers in North America with a steelmaking and rolling mill capacity that exceeds 1 million tpy. It has sales of approximately $2 billion.

Slater Industries Inc.

Control of the company was acquired by Fobasco Limited, a Fingold family holding company. Subsequently, the company announced its intention to diversify. The first move in this diversification was the purchase of Renown Steel and Melburn Truck Lines, two unincorporated divisions of Fobasco Limited.

Capital expenditures for 1987 of approximately $16 million were approved. These projects will increase production efficiency and improve quality control. Projects completed in the 1986 fiscal year included the installation and commissioning of a ladle furnace, a "laser beam" roll setting system and bottom pour ingot systems.

SLACAN, the division that manufactures poleline hardware, will be relocated in a new facility in the city of Brantford, Ontario in 1987.

WORLD DEVELOPMENTS

Rapid changes continued to occur within the steel industries of the western world. Developing nations, many of which have expanded steelmaking capacity, were exporting aggressively. Steel industries in the highly industrialized countries continued to react to depressed markets and oversupply by closing obsolete plants as well as rationalizing and modernizing remaining facilities. Barriers to unfairly traded steel were erected by most developed countries. In the United States, steel production capacity was reduced from the 1980 peak of 146 million t to 116 million t in 1986. A further 18 million t is likely to be closed by the end of the decade. In the European Community, capacity was reduced to 122 million t in 1985, but there was very little change in 1986. Japan's steelmaking capacity has been reduced slightly to about 140 million t. However, Japanese steel mills were predicting cuts in both plant and employment levels for the near future.

The cost of producing steel in the highly industrialized countries has been reduced partly by rationalization, partly by investment in new steelmaking technologies, and partly by a reduction of manning rates. The relative cost of steel production in North America has also been reduced by a drop in the value of the Canadian and American dollars relative to the Japanese yen and European currencies.

An indication of the improvements in productivity has been the change in person hours required to produce a tonne of steel. This figure dropped during the 1980 to 1985 period from 8.2 to 5.0 in the EC, from 10.1 to 6.2 in the United States, and from 5.9 to 5.6 in Japan. Labour productivity in Japan actually increased to 6.1 person hours per tonne of steel in the 1981 to 1983 period. The reluctance of Japanese companies to lay off employees was a major factor in the increase.

Developing countries increased their steel capacity from 75.3 million t in 1979 to 125.4 million t in 1986, an annual growth rate of 6.1 per cent. Growth is expected to continue in these countries at a rate in excess of 7 per cent per year for the next decade. Although developing countries have rapidly increased their steelmaking capacity, their labour productivity tends to be quite low. For example, person hours per tonne of steel produced in South Korea and Brazil during 1985 were 8.0 and 14.6 respectively.

The United States steel industry continued to improve its competitiveness by closing obsolete capacity and reducing operating costs. The premium paid to steelworkers relative to other industrial workers in the United States declined and will likely continue to decline as unions compromised their wage demands to avoid further closures or more Chapter 11 actions. Chapter 11 is a stage in bankruptcy which allows companies to break existing contracts.

Capacity in the EC continued to decline but remained much greater than demand. EC steelmakers recommended that price and production regulations, which were imposed by the European Commission, be maintained until 1990. During the year, quotas on a range of products were relaxed from 85 per cent to 60 per cent of production at year end. The commission stated that these quotas will be tightened for the first quarter of 1987.

In summary, world steel capacity in 1986 was still approximately one billion t, considerably higher than the 714.2 million t of production which was estimated by the International Iron and Steel Institute (IISI). Accordingly, surplus steel capacity will likely persist for many years, as will intense competition for markets.

PRICES

The ongoing recovery in the domestic economy allowed price increases in some product lines, that were in high demand even though overall demand declined in 1987. However, increases were constrained by the availability of low-priced imported steel.

Price changes were reflected in the Primary Steel Industry Price Index, published by Statistics Canada. For 1984, the "Iron and Steel Products" index (1981=100) averaged 112.9; in 1985 it averaged 115.1 and by 1986 it was 116.5.

Premium blends of coking coal, which was imported from the United States on a long-term contract basis, was $Cdn 72-74 a t at Ontario steel mills at year-end 1986, unchanged from 1985.

OUTLOOK

The Canadian steel industry can expect a drop in demand for its products of about 5 per cent in 1987. The robust demand for steel-intensive consumer durables that has been a characteristic of the economic recovery is expected to wane as consumers rebuild their savings to more traditional levels. A high level of spending from savings occurred in 1985. For example, automobile sales which have been brisk for the last three years, are forecasted to decline 3 to 4 per cent from the 1986 level. However, the resultant decline in steel demand should be tempered by the start-up of production in new automobile plants in Canada because cars that are now imported will be at least partially made in Canada. Renault, Honda, Toyota and Hyundai are the manufacturers involved.

Appliance sales are predicted to be strong in 1987 because of the high level of residential construction that occurred in 1986 and indications are that this trend will continue in 1987. Furthermore, the generally favourable economic conditions and low interest rates should stimulate replacement sales.

Although capital investment is forecasted to be quite strong in some sectors of the economy, it will be less in total than in 1986. The growth in non-residential construction is likely to be small, and oil and gas related investment could be especially depressed. Expenditures on machinery and equipment could slow by the end of 1987.

Canadian steel production in 1996 is forcasted to be over 16 million t. Canada will probably remain a net exporter of steel in the intermediate term, with most of its exports going to the United States. Imports will likely maintain a significant market share and could continue to depress prices. However, improved efficiency at Canadian plants, as current capital investment projects are completed, coupled with recent shifts in currency rates should allow Canadian firms to be more price competitive.

In view of the capacity expansion in developing countries and the excess capacity in industrialized countries, a world oversupply of steel is projected for the next 10 years. Furthermore, the substitution of other materials for steel will probably continue, especially plastics and aluminum alloys for steel in the production of automobiles, and aluminum and plastic fiber composites instead of steel in food containers. Industrial packaging will also tend to utilize progressively less steel. Although the fundamentals will still exist in 1996 for over-producing steel, the capability to do this will be considerably reduced from the situation in 1986.

TABLE 1. CANADA, GENERAL STATISTICS OF THE DOMESTIC PRIMARY IRON AND STEEL INDUSTRY, 1984-86

		1984	1985	1986P
Production				
Gross Domestic Production at Factor Cost				
Manufacturing industries	1981=100	62,211.3	65,194.2	66,255.8
Primary steel industries	1981=100	2,233.3	2,202.8	2,176.8
			($ million)	
Value of shipments, iron and steel mills[1]		7,442.7^{r}	7,695.6	..
Value of unfilled orders, year-end, iron and steel mills		788.6^{r}	932.7	..
Value of inventory owned, year-end, iron and steel mills		1,910.8^{r}	1,948.9	..
			(number)	
Employment, iron and steel mills[1]				
Administrative		11,922	11,703	11,615
Hourly rated		37,574	35,713	33,612
Total		49,583	47,438	45,232
			($)	
Average earnings per 40 hr week, hourly rated		619.95	647.20	..
			($ million)	
Expenditures, iron and steel mills[1] (investment intentions in 1986)				
Capital: on construction		23.7^{r}	74.8^{r}	59.5
on machinery		166.2^{r}	349.3^{r}	601.6
Total		189.9^{r}	424.1^{r}	661.1
Repair: on construction		40.0^{r}	39.7^{r}	43.6
on machinery		761.9^{r}	721.5	747.0
Total		801.9^{r}	761.2	790.6
Total capital and repair		991.8	1,185.3	1,451.7
Trade, primary iron and steel[2]				
Exports		2,035.3^{r}	2,191.2	2,108.3^{e}
Imports		1,448.5^{r}	1,843.4	1,692.6^{e}

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] S.I.C. Class 291 - Iron and Steel Mills: covers the production of pig iron, steel ingots, steel castings, and primary rolled products, sheet, strip, plate, etc. This is a seasonally adjusted index. [2] Includes pig iron, steel ingots, steel castings, semis, hot and cold-rolled products, pipe, wire and forgings. Excludes sponge iron, iron castings.

P Preliminary; ^{r} Revised; ^{e} Estimated; .. Not available.

TABLE 2. CANADA, PIG IRON PRODUCTION, SHIPMENTS, TRADE AND CONSUMPTION, 1984-86

	1984	1985^{r}	1986^{e}
		(tonnes)	
Furnace capacity January 1[1]			
Blast	13 570 000	13 902 150	13 901 150
Electric	600 000	600 000	700 000
Total	13 170 000	13 170 000	14 602 150
Production			
Basic iron	..	..	..
Foundry iron[2]	..	..	..
Total	9 643 260	9 665 427	9 271 000
Imports			
Tonnes	5 268	10 079	11 511
Value ($000)	1,123	3,510	3,219
Exports			
Tonnes	392 135	574 111	491 384
Value ($000)	92,391	131,528	106,477
Consumption of pig iron			
Steel furnaces[3]	9 572 684	9 792 015	9 400 000
Consumption of iron and steel scrap			
Steel furnaces	7 382 914	7 038 809	6 757 000

Sources: Statistics Canada; Primary Iron and Steel (monthly).

[1] The capacity figures as of January 1 in each year take into account both new capacity and obsolete capacity anticipated for the year. [2] Includes malleable iron. [3] Includes pre-reduced iron.

^{r} Revised; ^{e} Estimated; .. Withheld to avoid disclosing company proprietary data.

TABLE 3. CANADA, CRUDE STEEL PRODUCTION, SHIPMENTS, TRADE AND CONSUMPTION, 1984-86

	1984	1985r	1986e
		(tonnes)	
Furnace capacity, January 1[1]			
Steel ingot			
Basic open-hearth	3 702 750	1 907 200	1 000 000
Basic oxygen converter	12 235 000	11 779 000	11 279 000
Electric	5 397 754	5 586 450	6 362 480
Total	21 335 504	19 272 650	18 641 480
Steel castings	573 971	797 053	799 030
Total furnace capacity	21 909 475	20 069 703	19 440 510
Production			(Jan.-Nov.)
Steel ingot			
Basic open-hearth)			
Basic oxygen)	10 734 502	10 553 639	9 087 306
Electric	3 833 337	3 978 349	3 713 157
Total	14 567 839	14 531 988	12 800 463
Continuously cast, included in total above	5 647 337	6 384 305	5 880 158
Steel castings[2]	131 365	105 500	89 117
Total steel production	14 699 204	14 697 488	12 889 580
Shipments from plants			
Steel castings	117 339	98 330	76 728
Rolled steel products	11 559 252	11 661 501	10 758 945
Total	11 676 591	11 759 831	10 835 673
		(000 tonnes)	
Exports, equivalent steel ingots	3 273.8	3 439 811	3 463.6
Imports, equivalent steel ingots	2 034.3	2 488.6	2 440.7

Source: Statistics Canada.

[1] The capacity figures as of January 1 in each year take into account both new capacity and obsolete capacity anticipated for the year. [2] Produced mainly from electric furnaces.

r Revised; e Estimated; .. Not available.

TABLE 4. CANADA, VALUE[1] OF TRADE IN STEEL CASTINGS, INGOTS, ROLLED AND FABRICATED PRODUCTS, 1984-86

	Imports			Exports		
	1984	1985r	1986e	1984	1985r	1986e
			($000)			
Steel castings	31,236	44,032	24,174	13,340	7,770	5,577
Steel forgings	21,477	20,449	24,969	92,179	81,910	35,072
Steel ingots	12,586	2,036	1,523	30,621	15,609	123,980
Rolled products						
Semis	44,212	32,793	12,062	47,868	17,185	116,055
Other	927,877	1,157,588	671,187	1,248,784	1,397,385	2,414,355
Fabricated						
Pipe and tube	323,696	433,403	246,183	341,722	364,015	354,252
Wire	89,368	104,807	70,658	168,138	175,952	201,456
Total steel	1,450,452	1,795,108	1,050,756	1,947,952	2,059,826	2,001,780

Source: Statistics Canada.
[1] The values in this table correspond with the tonnages shown in Table 5.
r Revised; e Estimated.

TABLE 5. CANADA, TRADE IN STEEL BY PRODUCT[1], 1984-86

	Imports			Exports		
	1984	1985r	1986e	1984	1985r	1986e
			(000 tonnes)			
1. Steel castings (including grinding balls)	19.4	27.3	32.3	8.5	3.8	4.5
2. Ingots	50.5	56.6	49.4	109.7	43.7	124.0
3. Semi-finished steel blooms, billets, slabs	133.7	88.0	186.6	139.4	33.0	116.1
4. Total (1+2+3)	203.6	172.0	268.3	257.6	80.5	244.6
5. Finished steel						
A) Hot-rolled						
Rails	26.4	67.5	60.8	76.4	99.6	114.3
Wire rods	231.6	223.2	308.5	336.4	322.2	337.7
Structurals	234.6	232.6	286.1	252.2	290.6	339.6
Bars	152.1	116.1	172.9	257.7	296.1	295.6
Track material	7.4	4.9	10.1	31.8	2.3	20.8
Plate	200.1	240.1	178.6	170.8	169.1	170.2
Sheet and strip	152.9	403.8	186.9	687.1	710.9	532.7
Total hot-rolled	1 005.3	1 290.6	1 057.3	1 618.4	1 881.0	1 792.1
B) Cold-rolled						
Bars	21.3	24.7	25.3	42.3	47.9	64.6
Sheet and strip	126.2	147.8	172.3	133.1	128.5	130.2
Galvanized	71.2	111.1	176.3	286.8	251.9	224.1
Other[1]	9.0	164.8	198.1	181.4	210.2	203.7
Total cold-rolled	367.7	448.5	572.0	643.7	638.6	622.3
6. Total finished steel (A+B)	1 373.0	1 737.4	1 629.3	2 262.1	2 519.4	2 414.3
7. Total rolled steel (2+3+6)	1 556.6	1 882.4	1 865.3	2 511.2	2 596.1	2 654.4
8. Total steel (4+6)	1 576.6	1 909.4	1 897.6	2 519.6	2 605.7	2 658.8
9. Total steel (raw steel equivalent)[2]	2 034.3	2 488.6	2 440.7	3 273.6	3 440.0	3 463.6
10. Fabricated steel products						
Steel forgings	6.6	6.7	6.7	44.4	37.6	35.1
Pipe	312.3	454.3	256.6	403.8	433.2	354.2
Wire	78.5	89.8	87.7	173.1	172.6	201.4
11. Total fabricated	432.4	505.8	370.1	621.4	643.4	590.8
12. Total castings, rolled steel and fabricated (8+11)	2 009.0	2 415.2	2 267.7	3 140.8	3 343.2	3 249.6

Source: Statistics Canada.
[1] Includes steel for porcelain enameling, terneplate, tinplate and silicon steel sheet and strip.
[2] Calculation: finished steel (row 6) divided by 0.75, plus steel castings, ingots and semis (row 4).
r Revised; e Estimated.

TABLE 6. PRICES FOR RAW MATERIALS AND SELECTED STEEL PRODUCTS, 1984-86[1]

	Currency	1984	1985	1986
Raw Materials				
Iron ore pellets, Lake Erie base price, per metric iron unit[2]	$US	86.9	86.9	86.9
Coal, blended metallurgical, imported for Ontario steel mills, per tonne	$Cdn	72-75	72-75	72-75
Scrap, Number 1 heavy melting, per tonne f.o.b. Hamilton	$US	86.12	69.50	74.00
Direct reduced iron, per tonne	$US	115-135	115-135	115-135
Basic pig iron, per tonne	$US	213.00	213.00	213.00
Steel Price Index 1981=100				
Iron and steel scrap 0614305		104.2	100.7	100.6[e]

Sources: Statistics Canada; Skillings Mining Review; Iron Age; Energy, Mines and Resources Canada.

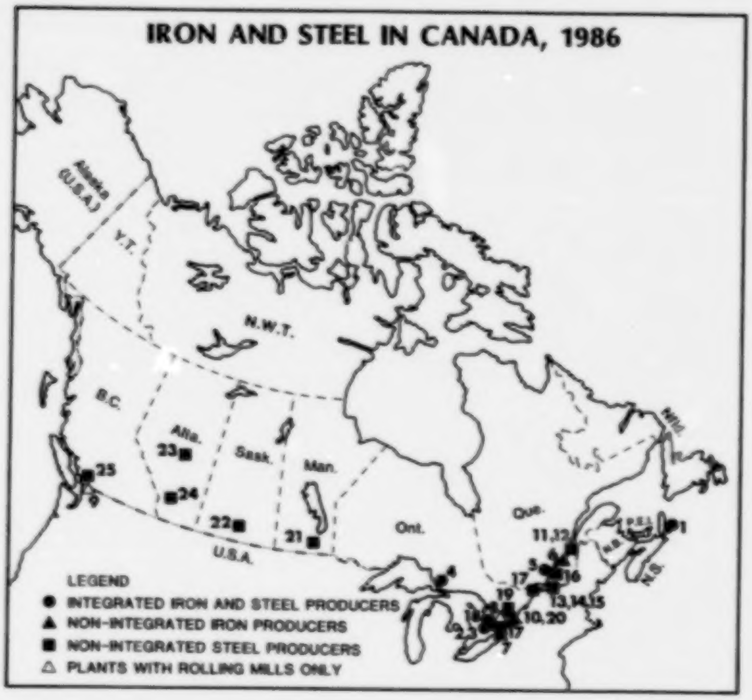
[1] Prices in effect at end of December of each year. [2] One iron unit equals one per cent of a tonne. Hence, iron ore pellets with a grade of 65 per cent iron would contain 65 iron units per tonne.

[e] Estimated.

TABLE 7. WORLD RAW STEEL PRODUCTION, 1985 AND 1986

	1985^r	1986^e
	(million tonnes)	
U.S.S.R.	154.5	160.0
Japan	105.3	98.3
United States	80.1	73.8
People's Rep. of China	46.7	51.9
F.R. of Germany	40.5	37.1
Italy	23.9	22.9
Brazil	20.5	21.2
France	18.8	17.9
Poland	15.8	17.4
Czechoslovakia	15.0	15.3
United Kingdom	15.7	14.8
Republic of Korea	13.5	14.6
Romania	13.8	13.8
Spain	14.2	12.0
Canada	14.6	14.1
India	11.5	11.9
Belgium	10.7	9.7
DPR Korea	8.4	9.0
South Africa	8.5	9.1
East Germany	7.9	7.9
Mexico	7.3	7.1
Australia	6.6	6.7
Taiwan	5.1	5.2
Netherlands	5.5	5.3
Turkey	6.0	5.0
Austria	4.7	4.3
Sweden	4.8	4.7
Yugoslavia	4.5	5.3
Hungary	3.6	3.8
Venezuela	3.5	3.1
Luxembourg	3.9	3.7
Argentina	2.9	3.2
Finland	2.6	2.5
Bulgaria	2.9	2.9
Others	16.8	17.5
Total	719.1	714.2

Source: International Iron and Steel Institute.
Note: Totals may not add due to rounding.
^{e} Estimate; ^{r} Revised.



IRON AND STEEL IN CANADA, 1986

Alaska (U.S.A.)
Y.T.
N.W.T.
B.C.
Alta.
Sask.
Man.
Ont.
Que.
Nfld.
N.B.
N.S.
P.E.I.
U.S.A.
LEGEND
● INTEGRATED IRON AND STEEL PRODUCERS
▲ NON-INTEGRATED IRON PRODUCERS
■ NON-INTEGRATED STEEL PRODUCERS
△ PLANTS WITH ROLLING MILLS ONLY
1
2,3
4
5
6
7
8
9
10,20
11,12
13,14,15
16
17
18
19
21
22
23
24
25

Integrated iron and steel producers
(numbers refer to locations on map above)

1. Sydney Steel Corporation (Sydney)
2. Dofasco Inc. (Hamilton)
3. Stelco Inc. (Hamilton and Nanticoke)
4. The Algoma Steel Corporation, Limited (Sault Ste. Marie)
5. Sidbec-Dosco Inc. (Contrecoeur)

Non-integrated iron producers

6. QIT-Fer et Titane Inc. (Sorel)
7. Canadian Furnace Division of Algoma (Port Colborne)

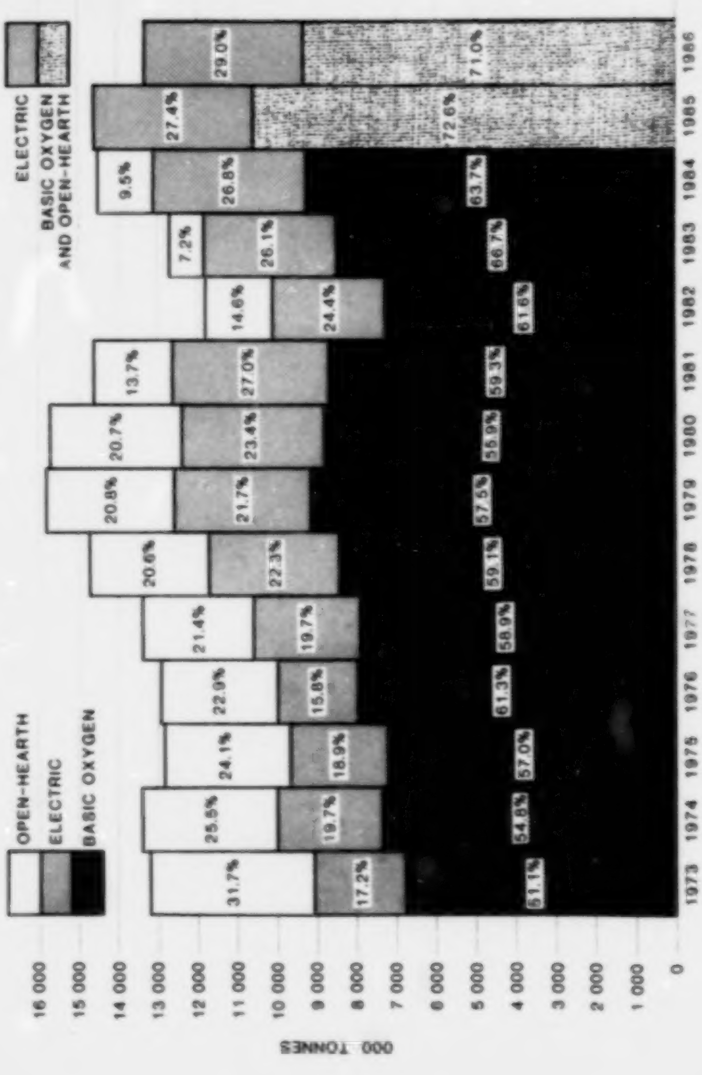
Plants with rolling mills only

8. Stanley Strip Steel division of Stanley Canada Inc. (Hamilton)
9. Pacific Continuous Steel Limited (Delta)

Non-integrated steel producers

10. Courtice Steel Limited
11. Stelco Inc. (Contrecoeur)
12. Atlas Steels, division of Rio Algom Limited (Tracy)
13. Sorel Forge division of Slater Industries Inc.
14. Canadian Steel Foundries, division of Hawker Siddeley Canada Inc. (Montreal)
15. Canadian Steel Wheel Limited (Montreal)
16. Sidbec-Dosco Inc. (Montreal and Longueuil)
17. Ivaco Inc. (L'Orignal)
18. Atlas Steels, division of Rio Algom Limited (Welland)
19. Hamilton Specialty Bar division of Slater Industries Inc.
20. Co-Steel Inc. (Whitby)
21. Manitoba Rolling Mills division of AMCA International Limited (Selkirk)
22. IPSCO Inc. (Regina)
23. Stelco Inc. (Edmonton)
24. Western Canada Steel Limited (Calgary)
25. Western Canada Steel Limited (Vancouver)

CANADA, PRODUCTION OF STEEL BY FURNACE TYPE



Lead

J. BIGAUSKAS

OVERVIEW

Although non-socialist world demand for lead rose by only 2 per cent to 4.1 million t, labour/management disputes, production cutbacks, shutdowns and closures set the stage for a jump in the price of refined lead from mid-1986. The average price of refined lead for 1986 was 22 cents (U.S.) per pound against 19 cents in 1985.

CANADIAN DEVELOPMENTS

Lead is mined, principally as a coproduct of zinc, in New Brunswick, British Columbia, the Northwest Territories and Yukon Territory. Smaller amounts are mined as a byproduct of polymetallic ores in Ontario and Manitoba. Primary lead metallurgical works are located in Belledune, New Brunswick and Trail, British Columbia. Nominal capacities of these lead plants are 72 000 tonnes per year (tpy) and 136 000 tpy, respectively, but effective capacities depend on feed material and other factors. Eight secondary lead plants - those recycling lead-bearing scrap - have a combined capacity of 118 000 tpy. These are located in Quebec, Ontario, Manitoba, Alberta and British Columbia. One of these plants, Tonolli Canada Ltd. in Mississauga, Ontario, will expand its present 25 000 tpy capacity by 7 000 t, by 1988.

In 1986, Canadian mines produced an estimated 350 000 t of lead in concentrates, some 65 000 t more than in 1985. Production of refined lead from all sources totalled about 265 000 t, up 25 000 t from that in 1985. Domestic consumption of refined lead, as measured by producers' shipments, is estimated at 110 000 t up 10 000 t, from the 1985 level. At the No. 12 mine of Brunswick Mining and Smelting Corporation Limited (BMS), operations were suspended for two weeks in July for market reasons and maintenance. In May 1986, BMS announced plans to spend $18.5 million over three and one-half years to deepen the No. 3 mine shaft by 200 m and install a deeper crusher at the No. 12 mine. The project had been deferred since 1978. A three-week annual maintenance shutdown was instituted in July at the company's Belledune, New Brunswick lead smelter.

Shareholders approved the purchase by Falconbridge Limited of Kidd Creek Mines Ltd's. assets in March 1986 (see "Zinc"). Kidd Creek produces a small amount of low-grade lead concentrate mainly as a byproduct of its "C" ore circuit at Timmins, Ontario.

A corporate reorganization of Noranda Inc. has led to the grouping of Noranda's Geco Division, Lyon Lake Division and 60 per cent owned Mattabi Mines Limited in northwestern Ontario into the newly-formed Noranda Mining Inc. operating unit. Together, these zinc-copper-lead-silver mines produce about 7 000 tpy of lead. Hudson Bay Mining and Smelting Co., Limited recovers a small amount of byproduct lead concentrate from its copper-zinc mines in Manitoba.

Cominco Metals, a Division of Cominco Ltd., announced in August that it would proceed with the modernization of its lead smelter at Trail, British Columbia. Cominco approved the $171 million first phase of the $260 million project following offers from the Province of British Columbia and the Government of Canada to invest $55 million and $79 million, respectively, in the project. Cominco Ltd. issued redeemable preferred shares which will bear interest at a floating rate tied to metal prices. The new smelter will have a capacity of 160 000 tpy, the same as the existing lead refinery, and will use the state-of-the-art QSL process developed by Lurgi GmbH. The first phase will be completed by late-summer 1989. The modernization project will increase the efficiency of metallurgical operations at the Trail plant and significantly improve environmental and hygienic conditions.

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Cominco Ltd. closed its Trail facilities from the end of July to the end of August for market and maintenance-related reasons. Similarly, its Sullivan mine at Kimberley, British Columbia, was shut down for six weeks in the summer. In October 1986, Canadian Pacific Limited completed the sale of its 52.5 per cent interest in Cominco partly to a consortium comprising Teck Corporation of Vancouver, M.I.M. (Canada) Inc., Metallgesellschaft Canada Limited and to an underwriting syndicate for public distribution.

Westmin Resources Limited produced several thousand tonnes of lead in concentrate from its newly expanded polymetallic operation in British Columbia. The new H-W mine reached commercial production rates in January 1986. Production resumed at the Faro, Yukon Territory, zinc-lead-silver mine of Curragh Resources Corporation in early-June 1986. This former operation of Cyprus Anvil Mining Corporation was closed in June 1982 because of heavy losses.

Pine Point Mines Limited, 51 per cent owned by Cominco, reactivated exploration on its property in May 1986. In late-1985 the company announced a new mining plan to improve profitability over the following two years. Cominco's Polaris zinc-lead mine was shut down at the end of June for six weeks. Mining operations in 1986 concentrated on removal of pillars from the Panhandle zone and advancement into the Keel zone. Canada Development Corporation agreed to sell its right to a 35 per cent royalty interest in the Nanisivik zinc-lead mine to Mineral Resources International Limited for $11 million. The operation, located on Baffin Island, produces lead and zinc concentrates.

WORLD DEVELOPMENTS

European mine production of lead was nearly unchanged in 1986 at 400 000 t, but refined metal production fell to 1 560 000 t in 1986 from 1 615 000 t in 1985. Consumption rose from 1 609 000 t to 1 650 000 t.

In August, Boliden AB announced plans to reduce the workforce at its Laisvall mine in Sweden and to concentrate on mining of richer portions. The Laisvall mine is Europe's largest producer of lead. About 55 000 t of lead are derived annually from 1.5 million t of ore.

AM&S Europe Ltd.'s ISP zinc-lead smelter at Avonmouth, United Kingdom was damaged in early-July. Reports suggested that plant would operate at a maximum of 80 per cent of capacity for the remainder of 1986. Annual capacity is 40 000 t of lead, in addition to zinc.

In Spain, Sociedad Minera y Metalurgica de Penarroya Espana S.A. closed its Cartagena lead smelter in March 1986 because of low lead prices. The plant was later expanded from 70 000 tpy to 90 000 tpy. The company declared force majeure on lead shipments from October to mid-November 1986 because of problems with its new furnace. Cia. La Cruz, S.A. 20 per cent owned by Penarroya, closed its 50 000 tpy lead smelter from September to December. Low lead treatment terms and a shortage of concentrates led to a reduction in the operating rate to 50 per cent of capacity, consequently increasing its unit operating costs. Exploracion Minera Internacional (Espana) S.A. (EXMINESA) began production at its Troya zinc-lead mine in November 1986. Some 9 000 tpy of lead will be produced. Empresa Nacional Adaro S.A. Linares, Spain mine was closed permanently. Production was about 5 000 tpy of lead.

Société minière et métallurgique de Peñarroya S.A. announced plans for cutbacks at its two mines in France in June 1986. Production at the Les Malines and Saint Salvy mines was reduced from 300 000 tpy and 180 000 tpy, respectively, to 215 000 tpy and 170 000 tpy, respectively because of low prices for coproduct zinc.

Preussag AG of West Germany cut back production at its Hilfe Gottes mine at Bad Grund from April to August. Ore production was expected to fall to 300 000 t in 1986 from 440 000 t in 1985.

As part of a five-year (1984-89) strategy to diversify metallurgical operations and reduce dependence on overseas ore sources, Metallurgie Hoboken-Overpelt SA commissioned a second electric furnace for lead, zinc, silver, copper and tin recovery at its plant in Hoboken, Belgium. The first 7 000 KVA electric furnace was commissioned in September 1985. The cost of the two furnaces and ancillary facilities is about BFr 1,400 million. The furnaces will treat the 160 000 tpy of low-grade slag generated at the plant.

Bleiberger Bergwerks Union AG, the state-owned Austrian lead producer, expects the 7 000 t expansion of its 17 000 tpy smelter and the replacement of its existing 24 000 tpy refinery to be in full operation from 1987 and 1988, respectively.

In Italy, SAMIM S.p.A. originally planned to start up its new 84 000 tpy KIVCET lead smelter in the second half of 1986. The smelter is now expected to be fully operational from 1988, but the situation will be reviewed in 1987. SAMIM closed its ISP zinc/lead smelter for one month from mid-June for maintenance. Lead production was expected to fall to around 21 000 t in 1986 versus 23-24 000 t in 1985.

Yugoslavia's lead metal production is estimated to have been 130 000 t in 1986. Mine production will be increased with the start-up of the new Toranica mine of Sour Rudarsko-Metalursko Prerabotuvacki Kombinat "Zletovo-Sasa" (10 000 tpy) in 1988 and the Sastavci-Kizevak mine of Sour Hemijska Industrija "Zorka", (1 500 tpy) in 1989.

United States mine production of lead fell to 350 000 t in 1986 from 427 000 t in 1985. Refined primary and secondary metal production fell to 905 000 t from 1 025 000 t while consumption rose to 1 130 000 t in 1986 from 1 100 000 t in 1985.

The U.S. lead industry experienced major restructuring in 1986, beginning with the purchase by, Homestake Mining Company in mid-May of AMAX Inc.'s 50 per cent interest in the AMAX-Homestake Lead Tollers smelter/ refinery at Boss, Missouri, as well as AMAX's Buick mine, also in Missouri. Both operations were closed at month end pending the evaluation of cost-reduction options. Production in 1985 totalled 178 000 t of lead in concentrates and 120 000 t of refined lead. St. Joe Lead Co. closed its 204 000 tpy lead smelter at Herculaneum, Missouri, during July to help balance production and consumption and to allow maintenance work. Output at the time was at an annual rate of 170 000 tpy. Mining and milling operations at Viburnum, Missouri were not affected.

At the end of October, Fluor Corporation (St. Joe's parent) and Homestake Mining Company, combined their Missouri-based operations into a joint venture called Doe Run Co. Doe Run will be owned 57.5 per cent by St. Joe Minerals Corporation and 42.5 per cent owned by Homestake. The Buick and Brushy Creek mines will be reopened and the Herculaneum smelter will continue operating, but the Fletcher mine will be closed and the Boss smelter will remain closed. Production will be reduced to 205 000 tpy of refined lead.

On April 19, ASARCO Incorporated reduced production at its East Helena, Montana lead smelter from seven to five days per week due to a shortage of concentrates, but resumed full production on August 1. Part of the company's concentrate supply will come from its new West Fork mine. The company approved the expenditure of $US 3.3 million to complete construction at West Fork, which has been operating at half capacity since January 1986. It expected to reach full production of 46 000 tpy of lead, 7 000 tpy of zinc and 4 tpy of silver by mid-1987. Concentrates will go mainly to the company's Glover, Missouri smelter.

Hecla Mining Company shut down its Lucky Friday silver-lead mine in Idaho in April 1986 due to low silver prices. The mine produced almost 150 000 kg of silver and 32 000 t of lead in 1985.

Initial construction of dock and port facilities for Cominco's Red Dog project in Alaska was completed in September 1986. With Board approval given at the end of November 1986, construction of the 83-km road to the property is expected to begin in the spring of 1987. Open-pit mine development is expected to begin once access is completed, and full-scale mining should commence by 1991. Reserves are currently estimated at 77 million t of ore grading 17 per cent zinc, 5 per cent lead and 81 g/t silver.

Mine production of lead in Central and South America was nearly unchanged at 460 000 t in 1986. Refined metal production and consumption fell to 400 000 t and 270 000 t, respectively.

Industrias Penoles SA de CV closed its La Encantada mine at Ocampo, Coajuila in April. This mine produced some 11 000 t of lead-in-concentrates and large quantities of silver. The closure was partly offset by the opening of the Rosario mine of Industrial Minera Mexico S.A., which has a capacity of 6 000 tpy of lead, and the Sultepec mine of Cia. Fresnillo SA de CV with a capacity of 1 000 tpy.

Workers at the El Mochito silver-lead-zinc mine of Rosario Resources Corporation in Honduras began a month-long strike over wage demands on June 24. The mine typically produces some 27 000 tpy of lead, but expansion plans may boost this by 6 000 t by 1988.

Empresa Minera del Centro del Peru S.A. (CENTROMIN-PERU) declared force majeure on lead, zinc, silver, copper, bismuth and other metal and concentrate deliveries effective March 6, 1986, due to a strike by workers. Output in the first nine months of 1985 was 54 200 t of lead, 172 000 t of zinc, 33 000 t of copper and 276 t of silver. Some 12 000 t of lead production was lost during the dispute. The new 10 000 tpy Peruvian lead smelter of Empresa Nacional de Fundiciones (ENAF) started up in the fall after a delay of 9 months. This first privately-owned plant in Peru was built by owners of the Santa Rita mine. It is also expected to produce 40-42 tpy of refined silver.

Mine production, metal production and consumption during 1986 in Japan were 40 000 t, 350 000 t and 380 000 t, respectively, below or nearly the same as in 1985. In contrast, mine production, refined metal production and consumption all rose substantially in the rest of Asia to 110 000 t, 170 000 t and 340 000 t, respectively. Dowa Mining Co., Ltd. spun off its Kosaka-Uchinotari mine division at Akita and Hanaoka mines as separate entities effective October 1. The first will be renamed the Uchinotai mine. Combined ore production was reduced from 75 000 tpm to 60 000 tpm. A cutback was also instituted at other Dowa mines. Production at Dowa's three operating divisions is typically 14 000 tpy of lead in concentrates, but production has been less than this recently. Mitsui Mining & Smelting Co. Ltd.'s 99.8 per cent owned Japan Zinc Mining and Smelting Co., Ltd., reduced ore production at the Nakatatsu lead-zinc-silver mine in Fukui prefecture by 40 per cent to some 800 tpd in July. Toho Zinc Co. Ltd.'s Chigirishima 72 000 tpy smelter and refinery was shut down for furnace repairs from July 13 to August 2. Production loss is estimated at 4 500 t of lead. Nippon Mining Company Limited closed its Hanawa copper-lead-zinc mine on August 1. Output at the company's Shakanai copper-lead-zinc mine in Akita was cut from 25 000 tpm to 12 000 tpm from July.

In the Republic of Korea, Korea Zinc Co. Ltd. opened its new 35 000 tpy electrolytic lead refinery. Full design output was achieved in the fall of 1986. Thailand expects its first lead smelter/refinery to come on-stream in February 1987. Three mines in Kanchanaburi province owned by Thai Lead Metal Company are expected to provide all of the feed for the 12 000 tpy plant. Plans to expand the plant over three years to 20 000 tpy are also reported. Kanchanaburi Exploration and Mining Co., Ltd. (KEMCO)'s Sang Do mine was expanded by 2 000 tpy to 17 000 tpy of lead.

African mine production of lead fell to 240 000 tpy in 1986 from 262 000 t in 1985, mainly due to the closure of a major Moroccan mine. Refined metal production and consumption were both 140 000 t in 1986.

The large lead-producing mine of Société de Development Industriel et Minière de la Haute Moulouya (SODIM) at Zaida, Morocco, was reported to have closed in late-1985. Production of lead was about 49 000 tpy. Société Tunisienne d'Expansion Minière (Sotemi) closed its Sidi Bouaouane mine, in Tunisia in November 1986. Production typically was 2 400 tpy of lead and 1 900 tpy of zinc. Zambia Consolidated Copper Mines Limited (ZCCM) shut down its zinc-lead mine and Kabwe ISP zinc-lead smelter for rehabilitation. Some 17 000 t of refined lead production was expected to be foregone. Capacity at the ISP plant is 30 000 tpy of lead metal. The Pehring zinc-lead mine in South Africa came on-stream in October. Full production will be 60 000 tpy of zinc and 5 000 tpy of lead. The output will be treated at the Tsumeb Corp. Ltd. complex in Namibia.

Australia's mine production fell to an estimated 420 000 t of lead in 1986 from 474 000 t in 1985, mainly because of labour/management disputes in the Broken Hill district. Lead and zinc are produced by three mining companies, New Broken Hill Consolidated Ltd. and The Zinc Corporation, Ltd., which are subsidiaries of CRA Limited, and North Broken Hill Holdings Ltd. Refined metal production also fell - to 175 000 t from 216 000 t - largely for the same reason. Metal consumption was nearly unchanged at about 60 000 t. CRA Limited's subsidiaries, Zinc Corporation and New Broken Hill closed their Broken Hill, Australia mines for two weeks on April 7 to consider their future after negotiations on changing work practices failed. Later the three zinc-lead mines at Broken Hill were shut down in late-May 1986 because of union/company disputes over work practices. The Broken Hill mines reopened on July 22 after the eight-week industrial dispute. Production from the Woodlawn open-pit operation of CRA is scheduled to cease at the end of 1986, but underground mining at an annual rate of 500 000 tpy to 600 000 tpy of ore is expected to begin in 1987.

Feed shortages at The Broken Hill Associated Smelters Pty. Ltd. (BHAS) in early-1986 led to a five-week shutdown beginning in mid-January at the 250 000 tpy smelter/refinery at Port Pirie, Australia. Shortages of concentrate from the eight-week industrial dispute at Broken Hill again led to depletion of concentrate stocks at BHAS near the end of July. The company resumed production on October 11 after a two-month halt.

STOCKS

Month-end stocks of refined lead on the London Metal Exchange (LME) fell from 68 400 t at the end of January to 37 700 t at the end of December 1986.

In February 1986, the U.S. Administration made a proposal to sell some 36 000 t of lead in fiscal year 1987, among other sales. The money was to be used to reduce the U.S. budget deficit. A joint House-Senate Bill was sent to the U.S. President in October 1986. This bill does not allow for sales from the 545 000 t U.S. General Services Administration stockpile.

PRICES

The average settlement price of lead on the LME fell gradually from a monthly average of £259/t in January to £247 in April 1986. Thereafter, it recovered temporarily in June, averaging £277, and after a temporary drop rose to an average £360 per t in December. On August 1, "Metals Week" introduced new price measures to reflect changing market conditions - the North American Producer Mean Price and the North American Producer Low Price. The Metals Week U.S. Producer Price was abandoned in October. The U.S. Producer price of refined lead, as reported by "Metals Week", jumped from an average of 18 to 19 cents a pound in January to an average of 22 cents in June 1986. Thereafter the price rose steadily until September when it averaged 23 cents. The North American Producer Mean and North American Producer Low rose from an average of 23 cents in September to an average of 29 and 28 cents, respectively, in December 1986.

USES

Lead's malleability allows it to be rolled to thicknesses down to 0.01 mm for use in gaskets, washers, impact extrusion blanks, soundproofing radiation protection and architectural applications. Lead can also be extruded in the form of pipe, rod, wire or other cross-sections and can also be extruded around power cables. Flux-cored, tin-lead solders and cable sheathing are typical extrusions. The low melting point of lead allows the simple casting of counterweights, sailboat keels and minute diecastings for instruments. Type metal is noted for its ability to reproduce fine detail. Storage battery grids may be either cast or rolled and expanded. Grids, together with battery posts and battery oxides, represent the largest uses for lead. Lead shot is used in ammunition and or for weight or sound/radiation shielding where accessibility is a problem. Lead and lead alloy powder and flakes are added to pipe joint compounds, powder metallurgy products (such as bearings, brake linings and clutch facings), solder pastes, and are incorporated into rubber and plastics for soundproofing curtains.

Calcium, antimony, tin or arsenic are generally added to impart castability, strength or hardness to lead alloys. When added to steel, brass or bronze, lead improves machineability. Alloyed with tin, lead is used as a hot-dip coating alloy to produce terne-coated steel. Lead oxides and other compounds are used in paints, pigments, glazes and a wide variety of chemicals. Tetraethyl lead - a gasoline additive - continues to decline in importance but still represents a significant market particularly for primary refined lead. New uses and existing ones are being evaluated by the International Lead and Zinc Research Organization. Nuclear wastes are generated at about 15 300 tpy and this is expected to grow. One existing nuclear material container design would require 5.25 t of lead for each tonne of waste. Corrosion characteristics of lead and lead alloys in various environments are being tested for this application. Several projects are under way to optimize the performance of shallow-discharge (starting lighting/ignition type) and deep-discharge (traction type) lead-acid batteries, and to investigate glass-mat separations for preventing acid spillage. Testing of a load-levelling battery for large users and producers of electricity may lead to a large potential market - perhaps 1 to 5 million t worldwide in the long-term. Tests on a 400-kwh, lead-acid load-levelling battery will begin in 1987 at Chino, California. By discharging during peak consumption and recharging during off-peak hours, a load-levelling battery could reduce the need for installation of excess generating capacity.

The Lead Industries Association, Inc. continued its longer term efforts to improve existing markets for lead and find new high growth areas. During 1986, major activities focused on development of the battery-powered lift truck, airport ground support equipment and yard tractor markets. Further campaigns are planned for 1987. The LIA plans to actively participate in the effort of the Electric Power Research Institute (California), the International Lead and Zinc Research Organization (New York) and major electric utility and engineering firms in the development of the load levelling battery market. LIA also plans to further define market potential for uninterruptible power supply systems, automatic guided vehicle systems, electric golf cars and lead solder, and to further promote lead use in asphalt and PVC plastic stabilizers and roofing components. Public awareness campaigns on environmental health are another major part of LIA activities.

OUTLOOK

In recent years, the declining price of lead and consequent shortages of scrap have affected the competitiveness of the lead recycling industry. With the closure of major lead recycling facilities both in the United States and in Europe and the implementation of further regulations on the secondary lead industry by U.S. environmental authorities, scrap availability may improve regionally despite relatively low lead prices. On the other hand, primary lead smelters, which now compete more directly with the secondary lead sector, already face a tight raw material supply, particularly of clean lead concentrates. Falling treatment charges and falling or low prices for associated zinc, silver and copper have affected the economics of some primary smelters. New smelting technology apparently offers opportunities in the long-term for primary lead smelters to reduce operating costs, but financial and other considerations may demand constrain the necessary investment in the short-term. Higher prices beginning in 1986 may provide some relief to producers and may also provide more impetus to longer term planning.

Non-socialist world consumption is expected to improve only marginally in 1987, and stocks of refined lead are more likely to increase than decrease. In Canada, consumption could be augmented by automakers' decisions to construct several new assembly plants. Worldwide shifts in consumption will likely follow automobile industry trends to some extent. Yet, in the long run, overall non-socialist world market growth is expected to be slow - about 1 per cent per annum. The price of lead is expected to remain low by historical standards, in both the short-term and the long-term, but could become more volatile from year-to-year because of market and currency-related fluctuations.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
CANADA					
32900-1	Ores of lead	free	free	free	free
33700-1	Lead, old, scrap, pig and block	free	free	1¢/lb	free
33800-1	Lead in bars and in sheets	4.3	4.3	25	2.5
33900-1	Manufacturers of lead, not otherwise provided for	12	12	30	free

MFN Reductions under GATT (effective January 1 of year given)	1986	1987
33800-1	4.1	4.0
33900-1	11.1	10.2

UNITED STATES (MFN)			
602.10	Lead bearing ores per lb of lead content	0.75¢	0.75¢
624.02	Lead bullion (lead content)	3.5	3.5
624.03	Other unwrought unalloyed lead (effective until December 31, 1988)	3.0% but not less than 1.0625 cents per pound to December 31, 1988	
624.04	Lead waste etc.	2.5	2.3

EUROPEAN ECONOMIC COMMUNITY: (MFN)		1986	Base Rate	Concession Rate
26.01	Lead ores and concentrates	free	free	free
78.01	Lead unwrought	3.5	3.5	3.5
	Lead waste and scrap	free	free	free
JAPAN (MFN)				
26.01	Lead ores and concentrates	free	free	free
78.01	Lead unwrought			
	Unalloyed	6.2	7.5	6.0
	Alloyed	7.2	12.0	6.5
	Other	5.0	7.0	4.7
	Lead waste and scrap	3.2	5.0	3.2

Sources: The Customs Tariff, 1986, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated (1986), USITC Publication 1775; U.S. Federal Register Vol. 44, No. 241; Official Journal of the European Communities, Vol. 28, No. L 331, 1986; Customs Tariff Schedules of Japan, 1986.

TABLE 1. CANADA, LEAD PRODUCTION AND TRADE 1984-85 AND CONSUMPTION 1983-85

	1984		1985		1986P	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Production						
All forms[1]						
British Columbia	85 147	62,915	116 811	67,418	103 204	69,514
New Brunswick	71 752	53,003	68 375	39,462	76 901	51,454
Northwest Territories	90 198	66,647	77 083	44,488	80 991	54,283
Yukon	2 983	1,539	1 470	888	36 278	24,436
Ontario	9 478	7,004	3 812	2,200	6 582	4,407
Manitoba	817	604	740	427	696	336
Newfoundland	4 805	3,580	-	-	-	-
Total	264 301	195,292	266 292	154,845	303 502	204,437
Mine output[2]	251 903	..	204 995	..	296 000	..
Refined production[3]	170 043	..	173 220	..	170 000	..
					(Jan.-Sept.)	
Exports						
Lead contained in ores and concentrates						
Belgium-Luxembourg	38 090	8,207	11 534	2,043	12 910	2,792
France	2 201	516	1 981	400	1 471	316
Italy	2 626	672	5 356	1,035	7 870	1,545
Netherlands	2 973	1,325	-	-	-	-
Spain	-	-	-	-	2 364	683
West Germany	15 982	3,655	15 712	2,050	7 419	1,508
United Kingdom	2 311	606	3 380	653	2 309	441
United States	8 858	2,262	11 155	3,090	4 369	1,550
Japan	41 271	8,700	..	..	36 315	10,965
Total	114 720	26,241	..	..	75 027	19,801
Lead and alloy scrap, dross, etc. (gross weight)						
Belgium-Luxembourg	52	20	892	302	-	-
Netherlands	170	144	2 305	693	1 018	536
Spain	98	20	204	65	-	-
United Kingdom	187	64	767	636	778	404
West Germany	467	170	505	135	3 100	806
United States	3 633	1,002	2 116	1,010	1 081	514
Brazil	-	-	3 439	1,070	7 613	1,670
Korea, Republic of	136	66	447	76	-	-
Taiwan	677	112	168	29	3 779	599
Other	77	20	264	36	1 810	353
Total	5 461	2,418	11 222	3,640	18 979	4,912
Lead pigs, blocks and shot						
Belgium and Luxembourg	6 155	3,944	4 994	2,026	1 127	582
Italy	2 564	1,724	302	193	2 265	1,514
West Germany	2 064	1,030	1 095	483	1 002	639
United Kingdom	27 077	13,492	28 300	12,051	17 378	7,086
United States	79 088	53,498	73 954	37,811	60 342	33,279
U.S.S.R.	1 500	3,923	883	431	-	-
People's Republic of China	15	3	-	-	1 000	448
Other	5 726	3,020	4 575	2,469	1 720	786
Total	124 189	80,634	113 993	57,064	85 034	45,134
Lead fabricated materials nes						
United States	17 396	13,050	14 516	9,021	12 900	7,923
Other	1 030	748	1 506	1,284	4 451	2,663
Total	18 426	13,798	16 022	10,305	17 351	10,586

TABLE 1. (cont'd)

	1984		1985		Jan.-Sept. 1986P	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Imports						
Lead pigs, blocks and shot	6 313	4,352	5 675	3,433	3 389	2,017
Lead oxide, dioxide and tetroxide (gross weight)	1 222	1,381	2 069	1,920	1 296	1,357
Lead fabricated materials nes	653	974	513	893	616	906
Lead in concentrates	21 512	11,606	..	..	..	..
Lead in crude ores	52	12	295	98	-	-
Lead in dross, skimmings and sludge (gross weight)	46	10	-	-	35	7
Lead and lead alloy scrap (gross weight)	48 157	7,314	48 188	5,884	45 534	5,396

	1983			1984			1985		
	Primary	Secondary[5]	Total	Primary	Secondary[5] (tonnes)	Total	Primary	Secondary[5]	Total
Consumption[4]									
Lead used for, or in the production of:									
Antimonial lead	1 499	x	x	4 813	x	x	3 452	x	x
Battery and battery oxides	27 792	5 555	33 347	35 228	5 208	40 436	34 627	7 767	42 394
Chemical uses; white lead, red lead, litharge, tetraethyl lead, etc.	14 834	4 515	19 349	15 651	4 572	20 223	14 395	3 065	17 460
Copper alloys; brass, bronze, etc.	159	69	228	187	102	289	277	123	400
Lead alloys:									
solders	1 812	6 769r	8 581r	1 527	11 494	13 021	1 197	6 085	7 282
others (including babbitt, type metals, etc.)	158	4 767r	4 925r	61	296	357	821	2 082	2 903
Semi-finished products: pipe, sheet, traps, bends, blocks for caulking, ammunition etc.	4 799	x	x	4 815	x	x	4 080	x	x
Other lead products	2 977	x	x	3 328	x	x	3 134	x	x
Total, all categories	54 030	38 569r	103 056r	65 610	46 656	112 266	61 987	40 267	102 254

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Lead content of base bullion produced from domestic primary materials (concentrates, slags, residues, etc.) plus estimated recoverable lead in domestic ores and concentrates exported. [2] Lead content of domestic ores and concentrates produced. [3] Primary refined lead from all sources. [4] Available data, as reported by consumers. [5] Includes all remelt scrap lead used to make antimonial lead.

P Preliminary; r Revised; - Nil; .. Not available; nes Not elsewhere specified; x Confidential, but included in "other".

TABLE 2. CANADA, LEAD PRODUCTION, TRADE AND CONSUMPTION, 1970, 1975, 1980-86

	Production		Exports				
	All forms[1]	Refined[2]	In ores and concentrates	Refined	Total	Imports Refined[3]	Consumption[4]
				(tonnes)			
1970	253 063	185 637	186 219	138 637	324 856	1 995	85 360
1975	349 133	171 516	211 909	110 882	322 791	1 962	89 192
1980	251 627	162 463	147 008	126 539	273 547	2 602	106 836
1981	268 556	168 450	146 307	119 816	266 123	9 220	110 931
1982	272 187	174 310	106 744	146 130	252 874	5 661	103 056
1983	271 961	178 043	85 459	147 263	232 722	2 958	88 579r
1984	264 301	174 987	114 720	124 149	238 869	6 313	112 266
1985	284 595	173 220	..	112 993	..	5 675	102 254
1986P	303 502	170 000e	750 275	85 034[5]	160 061[5]	3 308[5]	110 000e

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Lead content of base bullion produced from domestic primary materials (concentrates, slags, residues, etc.) plus the estimated recoverable lead in domestic ores and concentrates exported. [2] Primary refined lead from all sources. [3] Lead in pigs and blocks. [4] Consumption of lead, primary and secondary in origin as measured by survey of consumers except for 1986 estimate. [5] January to September 1986.
P Preliminary; r Revised; e Estimated; .. Not available.

TABLE 3. CANADA, PRIMARY REFINED LEAD CAPACITY, 1986

Company and Location	Nominal Annual Capacity
	(tonnes of refined lead)
Brunswick Mining and Smelting Corporation Limited Belledune, New Brunswick	72 000
Cominco Ltd. Trail, British Columbia	136 000
Canada total	209 000

TABLE 4. NON-SOCIALIST WORLD REFINED LEAD PRODUCTION[1]

	1984	1985	1986e
		(tonnes)	
North America	1 225	1 265	1 170
Central and South America	363	421	400
Europe	1 609	1 615	1 560
Africa	140	159	140
Asia	499	521	520
Oceania	225	220	180
Total	4 061	4 201	3 970

Source: International Lead and Zinc Study Group, EMR estimates.
[1] From all sources but excluding lead from secondary materials treated by remelting alone.
e Estimated.

TABLE 5. CANADA, MAJOR LEAD-BEARING DEPOSITS CONSIDERED MOST PROMISING FOR FUTURE PRODUCTION

Company and Location	Deposit Name	Indicated Tonnage (000 tonnes)	Per Cent Lead	Lead Content (000 tonnes)
New Brunswick				
Anaconda Canada Exploration Ltd.[1] Cominco Ltd.	Caribou	44 600	1.70	757
Kidd Creek Mines Ltd. and Bay Copper Mines Limited	Halfmile Lake	12 350	2.52	311
Northumberland Mines Limited Kennecott Minerals Company	Murray Brook	23 700	0.86	204
		80 650	1.6	1 272
British Columbia				
Nanisivik Mines Ltd. Regional Resources Ltd. Canamax Resources Inc. Procan Exploration Company Limited	Midway Project	6 078	6.62	402
Curragh Resources Corporation Dome Petroleum Limited	Cirque	21 700	2.7	586
		27 778	3.6	988
Yukon Territory				
Curragh Resources Corporation	DY Zone Swim Lake	21 000 4 536	5.6 4.0	1 176 181
Hudson Bay Mining and Smelting Co., Limited	Tom	8 000	8.6	688
Abermin Corporation and Ogilvie Joint Venture	Jason	14 062	7.09	997
Placer Development Limited and USX Corporation	Howard's Pass	120 000	2.1	2 500
Novamin Resources Inc. and Barytex Resources Corp.	MEL	5 000	2.0	100
		167 603	3.4	5 642
Northwest Territories				
Cadillac Explorations Limited	Prairie Creek	1 452	11.16	162
Cominco Ltd. and Etruscan Enterprises Ltd.	Seven deposits	19 100	0.75	143
Kidd Creek Mines Ltd.	Izok Lake	11 023	1.4	154
Westmin Resources Limited Du Pont Canada Inc.	Seven zones	7 260	3.3e	240e
		38 835	1.80	699
Other, Canada		16 406	4.7	777
Canada		260 000	3.6	9 400

Source: Mine Reserves and Currently Promising Deposits, January 1985, Energy, Mines and Resources Canada, Mineral Bulletin MR 209.
[1] Property purchased by East-West Minerals NL in late-1986.
e Estimated by Mineral Policy Sector.

TABLE 6. NON-SOCIALIST WORLD REFINED LEAD CONSUMPTION[1]

	1984	1985	1986[e]
		(000 t)	
North America	1 265	1 199	1 240
Central and South America	260	287	270
Europe	1 638	1 609	1 650
Africa	107	128	140
Asia	664	677	674
Oceania	71	69	70
Total	4 005	4 010	4 090

Source: International Lead and Zinc Study Group, EMR estimates.

[1] Total consumption of refined pig lead, including the lead content of antimonial lead.

[e] Estimated.

TABLE 7. PRINCIPAL USES OF LEAD, MAJOR CONSUMERS, 1986[e]

	Europe	United States	Japan
	(per cent of total demand)		
Uses			
Batteries	45	72	66
Cable Sheathing	5	2	4
Pipe and Sheet	20	3	4
Chemicals[1]	20	10	17
Alloys	5	5	5
Other	5	7	5

[1] Including tetraethyl lead.

[e] Estimated, totals may not add to 100 per cent due to rounding.

TABLE 8. NON-SOCIALIST WORLD MINE PRODUCTION

	1984	1985	1986[e]
		(000 t)	
North America	642	712	700
Central and South America	469	464	460
Europe	420	393	400
Africa	273	262	240
Asia	137	153	150
Oceania	418	474	420
Total	2 359	2 459	2 320

Source: International Lead and Zinc Study Group, EMR estimates.

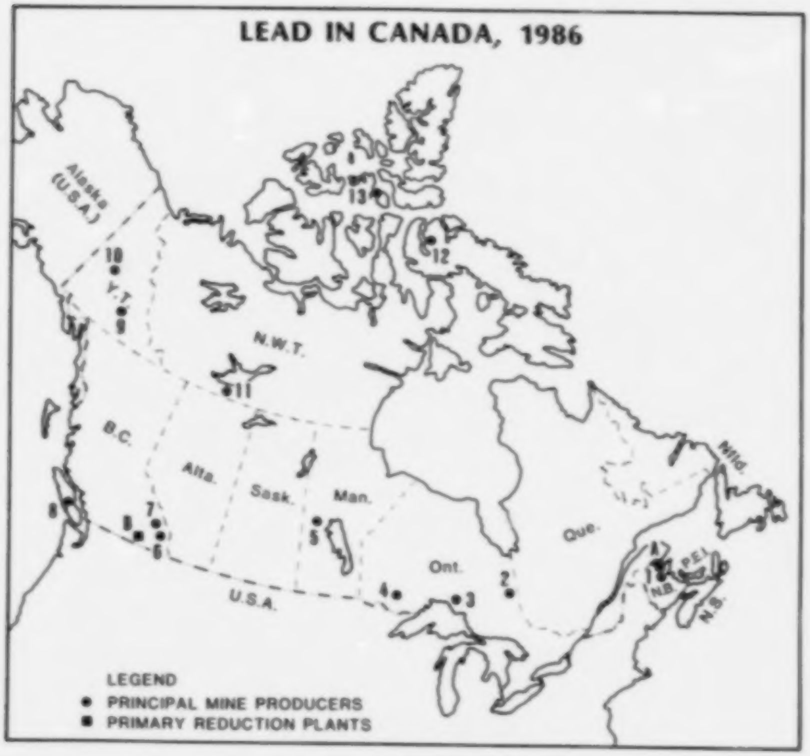
[e] Estimated.

TABLE 9. MONTHLY AVERAGE LEAD PRICES

	United States Producer[1]	Canadian Producer	LME Settlement
1985	(U.S. ¢ per lb)	(Cdn. ¢ per lb)	(£ per tonne)
January	19.1	26.5	373
February	18.8	25.4	337
March	17.7	24.2	313
April	19.9	27.2	315
May	20.1	27.5	301
June	19.0	26.4	304
July	18.9	26.0	292
August	19.1	26.0	299
September	19.2	26.8	294
October	18.9	26.0	277
November	19.0	26.0	274
December	19.0	26.0	270
Year Average	19.0	26.2	270
1986			
January	18.4	25.9	259
February	17.8	25.5	257
March	18.2	26.6	250
April	18.7	26.2	247
May	19.4	26.6	248
June	22.1	31.3	277
July	21.9	33.0	252
August	22.4	33.0	264
September	23.4	32.4	277
October	25.6	35.0	305
November	28.0	36.0	332
December	28.7	40.0	370
Year Average	22.0[2]	30.9	277

Source: Metals Week, Northern Miner.

[1] North American Producer Mean from October 1986. [2] Unofficial average, official average not available.


LEAD IN CANADA, 1986

Alaska (U.S.A.)
Y.T.
N.W.T.
B.C.
Alta.
Sask.
Man.
Ont.
Que.
Nfld.
P.E.I.
N.B.
N.S.
U.S.A.
1
2
3
4
5
6
7
8
9
10
11
12
13
A
B
LEGEND
● PRINCIPAL MINE PRODUCERS
■ PRIMARY REDUCTION PLANTS

Princial mine producers
(numbers refer to locations on map above)

1. Brunswick Mining and Smelting Corporation Limited
2. Falconbridge Limited (Kidd Creek)
3. Noranda Inc. (Geco Division)
4. Mattabi Mines Limited
   Noranda Inc. (Lyon Lake, "F" Group)
5. Hudson Bay Mining and Smelting Co., Limited
6. Cominco Ltd. (Sullivan mine)
   Teck Corporation (Beaverdell mine)
7. Dickenson Mines Limited (Silmonac mine)
8. Westmin Resources Limited (Lynx and H.W.)
9. Curragh Resources Corporation (Faro)
10. United Keno Hill Mines Limited (Elsa)
11. Pine Point Mines Limited
12. Nanisivik Mines Ltd.
13. Cominco Ltd. (Polaris mine)

Metallurgical Plants

A. Brunswick Mining and Smelting Corporation Limited, Smelting Division, Belledune

B. Cominco Ltd., Trail

Magnesium

G. BOKOVAY

Western world consumption of magnesium metal in 1986 is estimated at 226 000 t marginally higher than that recorded in 1985. With mounting inventories at the end of 1985, magnesium producers operated at slightly lower levels during 1986. Magnesium production in 1986 is estimated at 225 000 t compared to 233 900 t in 1985.

While the outlook for magnesium consumption in 1987 is somewhat uncertain, the longer term outlook remains positive. Demand for magnesium in aluminum based alloys, which currently constitutes the largest single use for the metal, is expected to remain constant or grow marginally, but magnesium demand in other sectors should more than compensate for this declining market over the next decade. In particular, it is expected that magnesium will find greater application in diecast products for the automotive industry.

With the planned construction of a new, low cost primary magnesium plant in Quebec by the Norwegian producer, Norsk Hydro AS, it is expected that competition in the important North American market will intensify.

CANADIAN DEVELOPMENTS

Chromasco a division of Timminco Limited is currently Canada's only producer of primary magnesium. The company operates a plant at Haley, Ontario, about 110 km west of Ottawa. Chromasco uses the Pigeon magnesium process in which calcined dolomite is reduced by ferrosilicon in a vacuum retort. The ferrosilicon used in the process is produced by Chromasco at Beauharnois, Quebec, while the dolomite is mined at the plant site.

Although the capacity of individual vacuum retorts is quite low and the cost of their maintenance is quite high, the process is energy efficient and the output is of extremely high purity. Chromasco currently markets four grades of primary magnesium ranging from 99.8 to 99.98 per cent purity as well as a wide range of magnesium alloys.

Calcium and strontium are also produced at Chromasco's Haley plant. Magnesium capacity at the plant is about 10 000 tpy. Although the plant operated at capacity for most of the year, an explosion in December which damaged the feedstock preparation circuit, caused some disruption to production.

In August 1986, Timminco announced a $23.3 million expansion program which will increase magnesium capacity by 50 per cent, strontium by 43 per cent and calcium by 25 per cent. At the end of 1986, phase one of the project, which includes the mechanization of magnesium crown processing facilities at Haley, was reported to be well under way. Phases two to four, which could begin in 1987, include the conversion of the Haley plant from electricity to natural gas and the improvement of the energy efficiency of existing furnaces.

In October, Norsk Hydro AS formally announced that it will proceed with a new 60 000 tpy primary magnesium plant at Bécancour, Quebec. Construction of the $400 million facility is expected to begin in the spring of 1987, with completion set for 1989. The new plant will create about 400 permanent jobs.

According to Norsk Hydro, the new plant will be based on its own low cost proprietary process technology, currently in use by the company in Norway. While the company will likely import magnesium oxide feedstock during the initial years of production, a possible expansion to 120 000 tpy could change the economics of raw material supply. In this regard, the company is examining several Canadian options including the construction of a magnesium oxide plant near Havre St. Pierre on Quebec's North Shore. Such a plant would utilize a dolomite/seawater process and cost between $100 and $150 million.

In November, the Oil, Chemical and Atomic Workers International, which represents magnesium industry workers in the United States, filed a formal request with

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the U.S. Trade Representative (USTR) for information about possible government subsidies in Canada for the Norsk Hydro plant. On December 24, American Metal Market reported that the USTR had provided the union with information. The USTR is also reported to have stated that remedies were available to the union, should it wish to proceed with a formal case.

In April 1986, the Aluminum Company of America (Alcoa) and MPLC Holdings S.A. announced that they would build a new 50 000 tpy magnesium plant at Aldersyde, Alberta. The project was to have been built in three stages with the first 10 000 tpy of capacity expected to be completed by 1988. Capital cost for the three phases was estimated at $375 million, with the Government of Alberta to provide loan guarantees up to $265 million.

However, Alcoa announced in October that it was withdrawing from the project. It was reported that Alcoa's decision was due to the company's unwillingness to depart from its overall strategy of backing away from basic commodity type businesses in favour of developing specialized materials.

Despite this setback, MPLC stated that it would look for other equity partners for the project. Construction, which was to have started in November 1986, is now rescheduled for April or May 1987. The company claims that its single stage process for converting magnesite to molten anhydrous magnesium chloride offers the potential for significant cost reductions in magnesium metal production and ultimately to an improvement in the competitive position of magnesium vis-à-vis aluminum.

Elsewhere in Canada, it was reported in February that Candol Developments Ltd. was involved in the early planning stages for a 20 000 tpy magnesium plant in southwestern British Columbia. In June, it was announced that Dow Chemical Canada Inc. was conducting a feasibility study for the possible development of Pamour Inc.'s magnesite deposit in northeastern Ontario. The magnesite would presumably be used as feedstock for magnesium metal.

WORLD DEVELOPMENTS

The International Magnesium Association (IMA) reported that for the first nine months of 1986, shipments of primary magnesium in the western world were 169 600 t compared to 168 200 t during the same period in 1985. The IMA also reported that western world production for the first nine months of 1986 totalled 168 600 t compared to 173 300 t for the similar period in 1985. On September 30, magnesium inventories were reported to be 46 000 t, compared to 43 000 t a year earlier.

The United States, which is the largest magnesium producer in the world, has three primary magnesium plants. The Dow Chemical Company, the largest U.S. producer, operates a 115 000 tpy electrolytic magnesium plant at Freeport, Texas. The magnesium chloride feedstock for the plant is derived from a seawater/dolomite process. During 1986 this plant was thought to have operated at about 75 per cent of capacity.

AMAX Magnesium Corporation operates a primary magnesium plant at Rowley, Utah. This plant, which utilizes an electrolytic process, has a capacity of about 34 500 tpy. Magnesium chloride feedstock is normally derived from natural brines of the Great Salt Lake. However, high water levels on the lake in June caused extensive flooding to the company's solar ponding system and disrupted raw material supplies. The magnesium plant continued to operate with purchased brines but it was reported that production had dropped to between one third and one half of capacity. AMAX abandoned its solar ponds in August and was reported to be exploring a number of supply options including the use of brine from a new state-built evaporation pond which is under development in the area. Another possibility is that AMAX may close its Rowley plant completely, particularly since it was reported at the end of 1986 that the company's president described the magnesium operation as being outside the company's core interests.

Northwest Alloys, Inc. a subsidiary of the Aluminum Company of America (Alcoa), operates a plant at Addy, Washington, that uses the Magnatherm process in which magnesium is produced by reducing dolomite with ferrosilicon. Capacity is about 32 500 tpy. During July, the company was reported to be operating at approximately 90 per cent of capacity.

Norsk Hydro, the second largest non-socialist magnesium producer, operates a primary magnesium plant at Porsgrunn, Norway. The plant produces magnesium by the electrolysis of magnesium chloride derived from both a seawater/dolomite process and magnesium chloride brines imported from West Germany. With the completion of a modernization program at the Porsgrunn plant in 1984, magnesium metal capacity is now about 60 000 tpy and may be expanded to 85 000 tpy within the next decade.

In Brazil, the Metalur Group's Companhia Brasileira de Magnesio (Brasmag), which produced about 4 000 t of magnesium during 1986, is proceeding with an expansion program at its plant in Minas Gerais state which will increase capacity to 35 000 tpy by 1988. The facility, which began production in 1981, uses a silicothermic reduction process which is reported to use 16 500 kwh of power per tonne of magnesium metal output.

Meanwhile in Norway, Brasmag along with Elkem A/S and other Norwegian interests are planning a new 15 000 tpy magnesium plant at Sauda Smeltwork, the site of an existing ferro manganese production facility. The joint venture operation, to be known as Norbrag AS, will utilize Brasmag technology, already in use in Brazil. Construction of the facility is scheduled to begin in 1987 with completion slated for 1989. The plant is expected to cost $US 75 million.

In Japan, Japan Metals & Chemicals Co. Ltd. announced during 1986 that it was shelving plans to build a 5 000 to 6 000 tpy magnesium facility. The company's decision was apparently influenced by the rash of new magnesium projects announced during 1986 in other parts of the world.

PRICES

During 1986, the price list for magnesium ingot (99.8 per cent purity metal in 10 000 pound lots, delivered) was steady at $US 1.53/lb. Meanwhile, the price of magnesium diecasting alloy was quoted at between $1.29 and $1.33/lb.

Since the specific gravity of magnesium is only two thirds that of aluminum, magnesium remains competitive on a volume basis as long as its price does not exceed 1.5 times the price of aluminum. However, with the price of secondary "380" aluminum diecasting alloy reported to be less than 60 cents (U.S.) per lb during 1986, magnesium was much more expensive.

USES

The largest single application for magnesium, accounting for over 55 per cent of non-socialist consumption in 1985, is as an alloying agent with aluminum. Aluminum/magnesium alloys have greater tensile strength, increased hardness, better welding properties and superior corrosion resistance than unalloyed aluminum. One of the most important applications for aluminum/magnesium alloys has been in beverage cans, which contain about 1.9 per cent magnesium. With greater recycling of can scrap in recent years, the demand for magnesium in this application has decreased somewhat.

One of the potential new uses for aluminum/magnesium alloys is in the aluminum foil industry. The addition of magnesium increases the strength of the foil and permits a thinner product.

The second largest use for magnesium is for structural applications, of which pressure diecast products constitute the most important component. After increasing from 21 000 t in 1982 to 29 700 t in 1985, the International Magnesium Association estimates than magnesium consumption in pressure diecastings will increase to 51 000 t in 1989.

As automobile manufacturers increase the fuel efficiency of their products, the use of lightweight parts including those of diecast magnesium is growing. Among some new or likely automotive applications for magnesium are transmission and transfer cases, clutch and axle housings, wheelrims, covers for grills, air cleaners, valves and also engine blocks.

A new cast magnesium bracket to support the brake pedal, steering column and clutch is planned by General Motors Corporation for its new W-body cars. The casting, which weighs about four pounds, will be manufactured in Canada by CAE Webster Ltd., a unit of CAE Industries Ltd. It is expected that this part will initially consume approximately 2 000 tpy of magnesium metal although this could increase to 7 500 tpy.

While the greater use of magnesium by the automobile industry is no doubt the result of more rigorous fuel economy requirements that have been adopted in the United States, high-purity magnesium alloys can be used in applications that were once considered too corrosive for the metal. In response to concern about corrosion, producers have announced the development of new, higher purity diecasting alloys or are placing more emphasis on existing high-purity products. An example is Chromasco's AZ91X diecasting alloy which contains a maximum of

0.004 per cent iron, 0.001 per cent nickel, 0.001 per cent copper and 0.01 per cent silicon. In addition to new alloys, the use of rapid solidification techniques using conventional powder metallurgy has been found to significantly improve the operating characteristics of finished products.

Aside from automotive applications, diecast magnesium products are widely used in the manufacture of portable tools and sports equipment. Magnesium usage in electronic equipment, particularly computers, has grown substantially and this trend is expected to continue.

Magnesium is also used as a deoxidizing and desulphurizing agent in the ferrous industry. Magnesium demand in this application, which has grown from about 8 400 t in 1982 to 19 100 t in 1985, is expected to expand to 33 000 tpy by 1989. The metal is also used to produce ductile or nodular iron and as a reducing agent in the production of titanium, zirconium and other reactive metals. Pure magnesium metal is used frequently for cathodic corrosion protection of steel structures, especially underground pipes and tanks. There are many uses for magnesium in the chemical industry including the making of Grignard reagents used in the production of tetraethyl lead for gasoline, although this use has declined in recent years as governments move to cut the use of these additives. Magnesium is also used in the fuel cladding material in Magnox-type nuclear reactors.

The use of magnesium in dry cell batteries is a fairly new application but one which has the potential for future growth in view of several recent design improvements. Unlike zinc-carbon or alkaline batteries, magnesium batteries have extremely long-shelf lives even at extremely high temperatures. This is due to a protective film of magnesium hydroxide which forms on the surface of the metal during storage periods. However, this protective film can cause a delay in the flow of full current when the battery is turned on, making the magnesium battery unsuitable for certain applications.

Potential new applications for magnesium which are currently being investigated, include magnesium/alumina, magnesium/silicon carbide and magnesium/graphite composite castings, hydrogen storage systems utilizing magnesium hydride, and a magnesium-sulphuric acid battery.

OUTLOOK

There are good prospects for significant growth in magnesium usage in diecasting and desulphurizing applications, although the anticipated decline in some other applications, such as aluminum alloying, will moderate growth in demand. Overall, magnesium consumption is expected to grow at an average annual rate of about 3 to 3.5 per cent to 1991.

Magnesium's price is currently at a level that makes it much more expensive in diecasting applications than aluminum. Although the aluminum market may recover somewhat in the next year, it is expected that aluminum prices will not exceed 60 cents (U.S.) per pound (constant 1986 U.S. cents) for the foreseeable future.

Despite the expected, relatively high level of growth in magnesium consumption during the next several years, an oversupply situation could develop by 1990 as several new primary magnesium plants come on-stream. Assuming that all announced developments proceed, primary magnesium capacity could increase by approximately 150 000 tpy (a 50 per cent increase) by the early-1990s. This is likely to force the closure of several older, higher cost production facilities and also worsen the already significant under utilization of magnesium capacity. However, in the longer term, the industry could benefit from increased competition and lower prices that would hasten the switch from aluminum to magnesium in diecasting applications.

With the construction of at least one large new primary magnesium plant incorporating the latest technology and having a stable supply of low cost electric power, Canada will undoubtedly become a major force in the world magnesium industry in the next decade both in terms of market share and competitive position.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
CANADA					
35105-1	Magnesium metal, not including alloys, in lumps, powders, ingots or blocks	4.2	4.2	25	2.5
34910-1	Alloys of magnesium; ingots, pigs, sheets, plates, strips, bars, rods and tubes	4.1	4.1	25	free
34911-1	Magnesium alloy ingots, for use in the production of magnesium castings (expires 30/6/87)	free	free	25	free
34912-1	Hardener alloys for use in the manufacture of magnesium castings (expires 30/6/87)	free	free	25	free
34915-1	Magnesium scrap	free	free	free	free
34920-1	Sheet or plate, of magnesium or alloys of magnesium, plain, corrugated, pebbled, or with a raised surface pattern, for use in Canadian manufactures (expires 30/6/87)	free	free	25	free
34925-1	Extruded tubing, of magnesium or alloys of magnesium, having an outside diameter of five inches or more, for use in Canadian manufactures (expires 30/6/87)	free	free	25	free
MFN Reductions under GATT (effective January 1 of year given)			1986	1987	
35105-1	Magnesium metal, not including alloys, in lumps, powders, ingots or blocks		4.2	4.0	
34910-1	Alloys of magnesium; ingots, pigs, sheets, plates, strips, bars, rods and tubes		4.1	4.0	
UNITED STATES					
628.55	Magnesium, unwrought, other than alloys and waste and scrap		10	8	
628.57	Magnesium, unwrought, alloys, per pound on magnesium content		6.6	6.5	
			¢ per lb of magnesium content + % ad valorem		
628.59	Magnesium metal, wrought, per pound on magnesium content		4.7¢ 2.6%	4.5¢ 2.5%	

Sources: Customs Tariff, 1986, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated (1986), USITC Publication 1775; U.S. Federal Register Vol. 44, No. 241.

TABLE 1. CANADA, CONSUMPTION OF MAGNESIUM, 1978-85

	1978	1979	1980	1981	1982	1983	1984	1985P
	(tonnes)							
Castings and wrought products[1]	952	1 447	1 412	619	574	490	550	435
Aluminum alloys and other uses[2]	3 001	3 003	4 000	5 768	4 431	5 078	6 296	6 129
Total	3 953	4 450	5 412	6 387	5 005	5 568	6 846	6 582

[1] Die, permanent mould and sand castings, structural shapes, tubing, forgings, sheet and plate. [2] Cathodic protection, reducing agents, deoxidizers and other alloys.
P Preliminary.

TABLE 2. CANADIAN IMPORTS/EXPORTS OF MAGNESIUM METAL

	Imports	Exports
	(tonnes)	
1980	3 419	5 316
1981	3 249	6 221
1982	1 972	4 501
1983	3 714	2 500
1984	4 287	4 022
1985	3 925	4 730
1986 (first nine months)	2 761	3 605

Source: Statistics Canada.

TABLE 3. WORLD PRIMARY MAGNESIUM PRODUCTION, 1980-85

	1980	1981	1982	1983	1984	1985
	(000 tonnes)					
Canada	9.3	8.8	7.9	6.0	8.0	7.0
United States	154.1	129.9	89.9	104.7	144.4	135.9
U.S.S.R.	75.0	76.0	77.0	80.0	85.0	86.2
Norway	44.4	47.6	35.9	29.9	48.3	58.9
France	9.3	7.3	9.6	10.9	12.8	14.0
Italy	9.7	10.8	9.9	9.8	8.2	7.9
China, People's Republic	7.0	7.0	7.5	8.5	8.5	7.3
Japan	9.3	5.7	5.6	6.0	7.1	8.4
Yugoslavia	0.5	3.9	4.2	4.7	5.1	5.1
Poland	0.5	0.5	0.5	-	-	-
Brazil	-	-	0.3	0.5	1.2	2.6
India	0.1	0.1	0.1	0.1	0.1	0.1
Total	319.2	297.6	248.4	261.1	328.7	333.4

Sources: World Bureau of Metal Statistics, American Bureau of Metal Statistics.
- Nil.

TABLE 4. PRIMARY MAGNESIUM PRODUCTION BY WORLD ZONE

Period	Area 1 United States & Canada	Area 2 Latin America	Area 3 Western Europe	Area 4 Africa & Middle East	Area 5 Asia & Oceania	Total
			(tonnes)			
1978	143 900	-	54 700	-	11 300	209 200
1979	156 400	-	58 700	-	11 400	226 500
1980	163 000	-	64 400	-	9 200	236 600
1981	138 400	-	64 400	-	5 700	208 500
1982	97 800	-	52 800	-	5 800	156 400
1983	109 000	-	51 000	-	6 000	166 000
1984	152 800	1 000	71 600	-	6 700	232 100
1985	142 900	2 000	80 800	-	8 200	233 900
1986 (first nine months)	99 400	2 700	60 500	-	6 000	168 600

Source: International Magnesium Association.
- Nil.

TABLE 5. PRIMARY PRODUCERS SHIPMENTS BY WORLD ZONE

Period	Area 1 United States & Canada	Area 2 Latin America	Area 3 Western Europe	Area 4 Africa & Middle East	Area 5 Asia & Oceania	Total
			(tonnes)			
1982	85 761	8 347	60 591	1 278	17 731	173 708
1983	98 600	9 600	60 400	2 400	33 400	204 400
1984	110 100	8 000	66 800	1 600	29 500	216 000
1985	102 400	9 400	72 200	2 400	38 400	224 800
1986 (first nine months)	77 800	8 000	54 000	2 500	27 300	169 600

Source: International Magnesium Association.

TABLE 6. WESTERN WORLD PRIMARY MAGNESIUM CONSUMPTION PATTERN, 1985

Use	North America	Latin America	Western Europe	Africa/ M. East	Asia/ Oceania	Total 1985
			(000 t)			
Aluminum alloying	52.7	4.1	36.9	1.9	29.4	125.0
Nodular iron	4.7	0.2	4.3	0.5	1.6	11.3
Desulphurization	13.2	-	5.8	-	0.1	19.1
Chemical/reduction	17.6	0.6	5.6	-	3.6	27.4
Diecasting	6.9	4.5	16.3	-	2.0	29.7
Other structural products	4.4	-	2.4	-	0.3	7.1
Other	2.9	-	0.9	-	1.4	5.2
Total	102.4	9.4	72.2	2.4	38.4	224.8

Source: International Magnesium Association.
- Nil.

Mica

M. PRUD'HOMME

SUMMARY

Canada is the world's leading producer of ground and flake phlogopite. Production is from a single mine situated near Parent in Suzor Township, Quebec, and a processing plant near Montreal. Phlogopite mica has traditionally been used as a filler in gypsum compounds, oil-well drilling muds and rubber products. For the last few years, ground mica has been intensively used in paints and, particularly, in plastics as a filler and reinforcing agent. Surface-treated mica and coated mica were new products introduced to capitalize on growth in the consumption of plastics.

In 1986, domestic production increased by 12 per cent. About 40 per cent of mica shipments were for exports to the United States and Japan. Late in 1985, Lacana Petroleum Limited of Toronto purchased the Suzorite mica operations from Marietta Resources International Ltd., and announced a major expansion plan to be completed by 1987 at a cost of $1.5 million. The expansion will increase the capacity of production of delaminated mica suitable for plastics.

E-Mica, a new mica grade, has been introduced for use as a reinforcing agent in housings for electronic components. These reinforced plastics are suitable for shielding microprocessors from electromagnetic interference.

In 1985, imports of ground mica declined by 3 per cent to 2 216 t, mainly to Ontario, Alberta and British Columbia. The total value of imports remained steady in 1985 at $4 million. The average unit value of imported ground mica increased by 16.7 per cent from $323/t in 1985 to $366/t in 1986.

On a nine-month basis in 1986, the value of imported mica products rose by 11 per cent to $3.4 million, largely as a result of higher imports of fabricated mica from the United States.

During 1986, prices for Canadian mica increased by 5 per cent and ranged between $170 and $750/t, f.o.b. plant.

The plastics industry is the main sector of growth for mica consumption, especially in the production of parts for automobile and domestic appliances. Chemically-modified micas will be increasingly used in polypropylene compounds to compete with more expensive substitutes. Sales of treated mica in North America are forecast to grow by 19 per cent annually for the period of 1985 to 1989.

THE MICA GROUP

Micas include a group of complex, isomorphic, hydrous aluminum potassium silicates with excellent basal cleavage and crystallize in the monoclinic system. The term "mica" primarily refers to muscovite $K\ Al_2\ (Al\ Si_3O_{10})(OH)_2$, biotite $K\ (Mg, Fe)_3\ (Al\ Si_3O_{10})\ (OH)_2$ and phlogopite $K\ Mg_3\ (Al\ Si_3O_{10})\ (OH)_2$.

Colour varies from black to virtually colourless. Hardness is approximately two to three on Mohs' scale, and density ranges from 2.7 to 3.1.

Essentially, only the muscovite and phlogopite varieties are of economic importance. Muscovite is a common constituent of acid igneous rock, such as granites, pegmatites and aplites. Phlogopite is particularly common in ferromagnesian basic rock, such as the pyroxenites, metasedimentary crystalline limestones, peridotites and dunites.

The micas are marketed in various forms, ranging from blocks and splittings to scrap: flake, ground and micronized.

Sheet mica is extracted from enormous crystals and worked by hand to obtain blocks, sheets and splittings. These grades are classified according to the size, thickness and colour of the sheets. Mica sheets are valued by the electrical and electronics industries for their dielectric, optical and mechanical properties.

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Scrap or waste mica is obtained from the production of sheet mica while flake mica is recovered from fine-grained micaceous rocks. Scrap and flakes are often indistinguishable in trade and production statistics, and both are used in ground mica production. These micas are classified according to particle size and are wet-ground or dry-ground.

SITUATION IN CANADA

Production and deposits

Canada produced mica continuously from 1886 until 1966 when the last shipment of phlogopite was made from the Blackburn mine in Cantley, Quebec. The Lacey mine near Sideham, Ontario, was a major phlogopite-producing site until 1948. From 1941 to 1953, Canada was one of the largest producers of sheet muscovite. The latter was extracted from the Purdy mine near Mattawa, Ontario. In 1977, mica production resumed in Canada, following development of a large deposit of phlogopite in Suzor Township, near Parent, Quebec.

There is only one mica operation in Canada at present, Suzorite Mica Products Inc., which mines phlogopite in Suzor Township, Laviolette County, and which processes flake mica at a plant in Boucherville, near Montreal. The deposit has a unique assemblage of schistose rock which contains approximately 80 to 90 per cent phlogopite mica, 4 to 8 per cent pyroxene, 2 to 6 per cent perthite and traces of apatite, calcite and chlorite. Phlogopite reserves are estimated at more than 27 million t of homogenous ore to a depth of 60 m.

The ore is open-pit mined on an intermittent basis every two years. A Kennedy Jaw Crusher breaks the ore to smaller than 20 cm prior to shipment by rail twice each year to the Boucherville processing plant. The ore is then dry ground, concentrated in a pneumatic separator, and classified according to four sizes: -10+20 mesh, -20+40 mesh, -40+100 mesh, and over 100 mesh. Up to 24 grades of mica are produced at the plant.

Tailings of feldspathic materials are distributed as waste material. Flake mica, registered under the name of Suzorite, is used as a reinforcing agent in plastics and in composites. The ground varieties of phlogopite act as a filler in asphalt products, in gypsum caulking products, and in oil-well drilling muds.

Late in 1985, Lacana Petroleum Limited of Toronto purchased the Suzorite mica operations from Marietta Resources International Ltd. Lacana announced a major expansion program to increase the production of delaminated high aspect ratio mica, to modernize the research facilities, to improve the dust collection system and to allocate funds for the development of new mica products, mainly for plastics. The expansion will be completed by 1987 and will cost about $1.5 million.

The overall production capacity varies from 18 000 to 20 000 tpy as determined by the qualities required. Following the expansion, the production capacity will reach 25 000 tpy, including a 30 per cent increase for fine grades.

During 1986, production of phlogopite mica rose by 12 per cent in terms of volume. Mica products were shipped to the United States, Japan and Europe. A new mica grade has been marketed for reinforcement in electromagnetic interference plastic shieldings. E-Mica is a nickel coated mica which is used as an electro-conductive filler in the production of strong conductive plastics in housings for microprocessors and other sensitive electronic components. Nickel-coated mica introduces reinforcement and good electrical properties with loading varying between 10 and 35 per cent. The products cost approximately $US 8.00/lb. In 1986, the rate of production is about 70 per cent overall, and 100 per cent for the production of fine grades.

Occurrences of mica have been discovered at several sites in Canada. Muscovite is particularly common in pegmatitic intrusions. Interesting occurrences were located in the following Ontario townships: Addington, Calvin, Canney, Chapman, Chisholm, Christie, Clarendon, Davis, Deacon, Hungerford, Kaladar, Lennox, Mattawa, McKonkey, Olrig and Sheffield. In Quebec, muscovite is found in the counties of Abitibi-Temiscamingue, Charlevoix, Dubuc and Saguenay; in British Columbia, near Yellowhead Pass, the Big Ben District of the Columbia River, and in the Fort Grahame District.

In Canada, phlogopite is virtually confined to the northeastern belt of the Grenville series. The major occurrences of phlogopite are found in Quebec in the counties of Argenteuil, Gatineau, Hull, Labelle, Laviolette, Montcalm and Papineau, and in Ontario in the counties of Frontenac and Lanark.

Exploration and development

During 1986, Lacana Mining Corporation undertook an exploration program at its muscovite deposit near Kaladar, Ontario, optioned from Koizumi (Canada) Ltd. of Toronto. Samples will be processed to determine grindability and flake recovery, and diamond drilling will provide new data for reserves estimation.

Commercial Industrial Minerals Limited optioned a tremolite-mica-talc property from Ram Petroleum Ltd. near Clarendon, Ontario. There was production of a variety of tremolite separated by dry screening and marketed under the trade name "Clarendite". Reserves contain 130 000 t of phlogopite mica.

Some exploration work for muscovite mica has been carried out in British Columbia near Logan Lake (Cominco Ltd.), Raferty Lake (Pacific Mica Resources Corporation) and in northern B.C. (Tamars Engineering Ltd.).

USES AND SPECIFICATIONS

The principal commercial types of mica are muscovite (potassium mica), accounting for over 80 per cent of commercial trade, and phlogopite (magnesium mica), and both are utilized in the sheet and flake forms. Ground mica has the largest use. Scrap and flake are either dry-ground (75 per cent of production), wet-ground or micronized.

Sheet mica is used for its electrical and insulating properties, principally in electronic markets. Ground mica is used mainly as a filler in building products and in paints, as a reinforcement in plastics, and as a component in oil-well drilling muds.

Sheet mica is graded according to thickness: blocks must be thicker than 0.007 in. (0.18 mm), films between 0.0008 and 0.004 in. (0.0206-0.1328 mm), and splittings approximately 0.0011 in. (0.0028 mm). Sheet mica is used mainly in the electrical and electronics industries, and in small quantities for thermal insulation. Sheet muscovite is used to manufacture micanite, mica paper and fabricated products, such as capacitors and commutator segments. Since the dielectric properties of muscovite are better than those of phlogopite, transparent mica is the most common variety used in those sectors. The specifications for sheet mica comply with the standards of the American Society for Testing and Materials (ASTM). Designation ASTM-D351-62 specifies quality according to stain, inclusions and imperfections. Designation ASTM-D2131-65 specifies the required characteristics for mica product manufacture. Designation ASTM-D748-59 defines the requirements for the electrical, physical and visual properties of the mica sheets used in capacitors.

Mica paper, glass-bounded mica, and phosphate-bonded mica are manufactured mica products and represent cheaper alternatives to sheet mica. Electrical and electronic uses for smaller grades of sheet mica have declined rapidly due to the introduction of the printed circuit and the silicon chip.

Ground and micronized micas are used as reinforcing agents or fillers. The major uses are in gypsum caulking products, asphalt roofing products, paints, rubber products, plastics, and oil-well drilling muds.

Dry wall products and joint cement compounds constitute the major use for mica. Mica prevents cracking and provides good workability due to its structural quality. Product size should be less than 150 microns and it should be free of abrasive grits. Muscovite is occasionally preferred over phlogopite as it is virtually colourless. In this use, the principal substitutes for mica are talc, clay and asbestos.

Mica is used in asphalt roofing products as a dusting agent. It is also used as a filler in asphalt mixtures to improve their resistance to weathering. Dry-ground mica varies in size from 850 to 75 microns (20 to 200 mesh).

Paints require fillers to improve surface qualities. Mica reduces shrinkage, prevents cracking and improves resistance to weathering. It is used in exterior paints, anticorrosive emulsions and oil-based metal primers. Wet-ground or micronized mica should be transparent and have particle sizes in the order of 100, 160 and 325 mesh, and over 30 microns.

Producers of rubber materials use mica as a dusting and releasing agent. It is also used as a filler to reduce gas penetration and shrinkage during moulding. The mica is generally in 850 to 150 micron flakes.

Plastics are a growing application for micas which are used as fillers, primarily in phenolic and epoxy resins imparting dielectric, thermal and mechanical improvements. Reinforcement of plastic resins with mica flakes, by replacing or supplementing other fibrous minerals such as wollastonite or asbestos, has been growing because of the commercial availability of high aspect ratio mica grades, the introduction of surface-treated grades, and the extensive development work towards optimizing compounding and processing conditions. Micas with a high diameter to thickness ratio (High Aspect Ratio, HAR) are used in polypropylenes, polyethylenes and phenolic plastics. The resulting plastics have high modulus of elasticity, flexural and tensile resistances, increased heat distortion and deflection temperatures, low permeability and good resistance to weathering. Delaminated micas are treated with coupling agents to improve their cohesion with resins. Treated micas are chemically surface-treated to be used in resins systems such as polypropylene and high-density polypropylene. These grades are the most expensive and they are substitutes for higher cost fiberglass. Loading levels range from 20 to 50 per cent by weight. These ground micas have a particle size ranging from 425 to 45 microns.

The majority of mica consumption in plastics is for polypropylene and higher-density polyethylene for automotive application.

Other principal uses of various types of mica include: mica splittings for built-up mica products such as molding plates, segment plates, heater plates and tapes through the use of binders, adhesives, and backing materials; dry-ground mica for insulation boards, oil-well drilling muds, welding electrodes, acoustical products, adhesives, fire extinguishers, foundry coatings, lubricants, and composite cement materials; wet-ground mica for wallpaper and lubricants.

CONSUMPTION AND TRADE IN CANADA

In Canada, mica is primarily consumed by the construction industry. More than 85 per cent of the mica is used in gypsum caulking products and paints. The rubber, plastics and drilling mud industries share the remaining 15 per cent.

Canada imports ground muscovite from the United States for asphalt roofing products and gypsum products.

The major consumer of mica in North America is the putty and caulking industries accounting for nearly 72 per cent of all mica consumed. The next largest market is the paint industry which accounts for 20 per cent; the plastics industry accounts for only 5 per cent of all mica consumed, but it is the major consumer of phlogopite and the major potential growth market for all mica.

In 1985, imports of ground mica declined 3 per cent to 2 216 t; however, the unit value increased 19 per cent to $323.56/t in line with an upward trend since 1982. The United States is the only exporter of ground mica to Canada, which is mainly shipped into Ontario (40 per cent), Alberta (26 per cent), British Columbia (19 per cent) and Quebec (7 per cent).

Imports of ground mica, on a nine-month basis, increased 2.1 per cent in terms of tonnage in 1986, compared to 1985. Imports of fabricated mica products increased by 19 per cent. The United States accounted for 83 per cent of total imports of fabricated mica products for use in Ontario (76 per cent) and Quebec (22 per cent). All sheet and scrap mica imports in Canada were from the United States (83 per cent) and India (17 per cent).

Canadian phlogopite mica is used locally in the gypsum products, rubber and plastics industries. Some is exported principally to the United States, Japan and Western Europe for use in the plastics industry. In the United States, imports of mica from Canada decreased by 8 per cent to 5 290 t in 1985.

WORLD PRODUCTION AND REVIEW

World production of mica can be broken down according to mica type. India is the most important source of muscovite sheet mica, followed by Brazil, Argentina and Madagascar. The United States, the largest producer and consumer of ground and flake mica, produces muscovite by wet and dry methods, generally as a coproduct of kaolin, lithium or feldspar. Canada, Finland and Argentina produce ground, flake and micronized phlogopite.

In 1985, world production of mica dropped 11 per cent to 246 000 t with the U.S.A. representing one-half of this total quantity. This decrease was largely caused by reduced production of scrap and flake mica in the United States with a decline of 15 per cent.

In the United States, the National Security Council recommended a restructuration of the strategic and critical stockpiles for mica blocks, films and splittings. By 1985, the government inventory of sheet mica was reduced by 3 per cent to 10 160 t. Ground mica production decreased by 7 per cent to 123 350 t; the decline is mainly due to reduced demand for mica used in oil-well drilling muds. Unimin Corporation of New Canaan in Connecticut announced the construction of a ground mica processing plant at Spruce Pine in North Carolina. This expansion by Spring 1987 will effectively double the capacity of the existing plant formerly owned by Harris Mining Co. The ground muscovite will be sold for use in construction and in petroleum markets in North America.

In Finland, Kemira Oy mined phlogopite as a by-product of apatite from the Siilingarvi mine. In 1985, this company started a commercial plant with a production capacity of 22 000 tpy for wet-ground mica. The facility will produce 10 000 tpy of coarse mica and 6 000 tpy of fine-ground filler mica, which will be mainly sold for use in oil-well drilling muds and construction industry products. Kemira Oy hopes to penetrate those markets identified as growth areas: asbestos replacement, automotive and the plastics industries. Kemira Oy has also developed a mica pigment coated with titanium dioxide. The pigment is suitable for pearlescent paint and for plastics.

In India, exports of processed mica increased 5 per cent in terms of value and 100 per cent in terms of quantity. During 1985-86, shipments of mica, at 22 150 t, were reported to be the highest ever achieved and were some 88 per cent higher than the 1982-83 levels. The state-owned Mica Trading Corporation of India Ltd. exported mica to some 30 countries including the U.S.S.R.; exports to the U.S.S.R. accounted for 60 per cent of India's sales of mica blocks and 25 per cent of its mica splittings and films sales. The Engineering Exports Promotion Council proposed to decanalize exports of processed mica in order to improve export levels.

PRICE

Prices for mica are based on type, grade and quality. Sheet mica grades are 10 times more valuable than ground mica grades. Imported sheet mica prices ranged from about $1.37/kg to $2.25/kg.

Prices for ground mica have increased for the last five years, reflecting the demand for higher grades and more sophisticated processing for chemically treated mica.

Prices of ground mica vary depending on colour, fineness, aspect ratio, quality and the method of processing. Prices for Canadian mica increased 5 per cent in 1986, ranging between $170 and $750 per tonne, f.o.b. plant.

OUTLOOK

The sheet mica producers' strategy is to put more emphasis on developing the production of fabricated mica, although these high-value-added products still require extensive manual labour.

In North America, the production capacity for ground mica exceeds demand; however, optimistic forecasts of expanding markets have resulted in work being started on several projects. This optimism in the ground and flake mica industry is linked to expected improved economic performance in the construction, plastics, drilling mud and insulation industries.

In the construction sector, manufacturers of paints, asphalt roofing products and gypsum caulking products consume more than 90 per cent of all mica used in Canada. World demand for mica, estimated at 220 400 t in 1983, is expected to reach 249 400 t in 2000, an average annual growth rate of 0.7 per cent as evaluated by the U.S. Bureau of Mines. Sheet mica demand will decline because of changing industrial technologies and because of greater use of substitute materials. Demand for ground mica is expected to continue to grow at an average annual rate of 0.7 per cent.

The main area of growth in the use of ground mica will be in the plastics industry, especially in the production of parts for automobile and domestic appliances. Production of plastics is dominated by the industrialized countries, mainly by the United States with 26 per cent of world total production of plastics, followed by West Germany (14 per cent), Japan (13 per cent) and the Netherlands (6 per cent). The world total production of plastics is forecast to increase by 7 per cent in the period of 1983 to 2000. In the United States, consumption of polypropylene is expected to increase by 5.4 per cent annually from 1981 to 1991. In Japan, polypropylene consumption rose by

6 per cent to 1.2 million t in 1985. In western Europe, polypropylene consumption rose by 9 per cent, following a 14 per cent increase in the previous years. Two factors should ensure rising demand in the plastics industry: higher consumption of polypropylene in the automobile industry, and the increasing use of mineral fillers to reduce production costs of plastics. The demand for reinforced plastics will increase in the packaging industry, in the automotive and electrical sectors as tailored compounds move the material into more engineering applications. Sheet molding compounds are increasingly used in the automotive sector. Plastic cans or containers will be marketed when shelf lives and recycling studies will be completed. Plastic sheet will be developed to compete with steel sheet.

In the gypsum plasterboard and caulking compounds industries, which are the largest end-uses for ground mica, the increase in demand is linked to activity of new construction. In paints, demand is quite stable and is also linked to construction activity. The improved quality of paint imparted by the use of mica will lead to increasing use in this field and will provide steady growth.

In oil-well drilling muds, the demand for mica has decreased drastically but will increase when activities in this industry resume. In insulation uses, mica consumption will be steady because of satisfactory growth and technical performance.

Chemically-modified micas are used in polypropylene compounds and compete with the more expensive fiberglass compounds. Chemical modification is generally employed to improve compatibility between a mineral and polymers. Sales of treated mica in North America are forecast to increase by 19 per cent annually to 1989. Compounding of chemically-modified mica in plastics will become an important method to enhance performance of polymers. The outlook for these products presents business opportunities to mineral suppliers interested in value-added production. Depending on the mineral and type of treatment, chemical modifications can add 3.5¢ to 50¢/lb. to the cost of the mineral.

PRICES

Average price[1] for wet-ground and dry-ground mica in the United States

	$US per short ton	
	1985	1986
Wet-ground mica	392	407
Dry-ground mica	123	130
By uses:		
drilling muds	107	106
paints	170	174
joint cement compounds	149	152

Prices for mica in the United States, according to the Chemical Marketing Reporter[2]

	$US per lb. 1986
Dry-ground mica: joint cement, plastics, 50-pound bags, carload, works	.07½
Dry-ground mica: roofing products, 20 to 80 mesh sieves, point of shipping	.07
Wet-ground mica: paints, per carload, 325 mesh sieve, f.o.b., works	.16¾
By uses; carload, f.o.b., works	
rubber products	.16¾
wallpaper	.22

	$Cdn per short ton	
Prices for phlogopite[3], f.o.b., works, carload	1985	1986
Super delaminated fine mica	248-443	260-470
Surface-treated mica	680-740	695-750
Flake or ground mica	295-410	310-438
Drilling fluid mica	113-177	170-194

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[1] U.S. Bureau of Mines, 1985, Mica. [2] CMR, December 1986. [3] Suzorite Mica Products Inc., July 1, 1986.
f.o.b. Free on board.

TARIFFS

Item No.		British Preferential	Most Favoured Nation (MFN)	General	General Preferential
			(%)		
CANADA					
29600-1	Mica schist	free	free	free	free
29650-1	Mica, phlogopite and muscovite, unmanufactured, in blocks, sheets, splittings, films, waste and scrap	free	free	25	free
44550-1	Raw low-loss mica, sheets and punchings of low-loss mica	free	free	25	free
UNITED STATES (MFN)					
516.11	Untrimmed phlogopite		free		
516.31	Split block mica		free		
516.41	Other		free		
516.51	Mica splittings		free		
516.61	Mica, not over 0.006" in thickness, not cut or stamped to dimensions, shape or form		free		

		1986	1987
		(%)	
516.21	Phlogopite, waste and scrap	4.4	4.2
516.24	Other mica, waste and scrap	2.4	2.4
516.81	Ground or pulverized mica	2.9	2.4

Sources: The Customs Tariff, 1986, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated 1986, USITC Publication 1775; U.S. Federal Register.

Note: Various other tariffs are in effect on cut and stamped mica and on mica manufacturing.

TABLE 1. CANADA, MICA IMPORTS, 1982-86

	1982		1983		1984		1985		1986P	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Rough, scrap and schist mica										
United States	..	24	..	52	..	53	..	18	..	13
India	..	134	..	0	..	0	..	0	..	0
Subtotal	..	158	..	52	..	53	..	18	..	13
Ground mica										
United States	2 378	590	2 632	680	2 287	622	2 216	717	2 143	809
Subtotal	2 378	590	2 632	680	2 287	622	2 216	717	2 143	809
Mica in blocks, films and sheets										
United States	481	250	157	191	84	128	59	212	31	69
India	1	2	1	6	24	18	35	48	0	0
Subtotal	482	252	158	197	108	146	94	260	31	69
Fabricated mica, nes										
United States	..	2,230	..	1,385	..	2,236	..	2,506	..	2,857
France	..	420	..	1,118	..	575	..	271	..	686
India	..	18	..	54	..	43	..	130	..	196
United Kingdom	..	88	..	115	..	173	..	113	..	1
Switzerland	..	7	..	2	..	0	..	16	..	0
West Germany	..	0	..	0	..	2	..	0	..	0
Hong Kong	..	3	..	0	..	0	..	0	..	0
Subtotal	..	2,766	..	2,674	..	3,119	..	3,306	..	3,740
Total rough, sheet, ground and fabricated mica	..	3,766	..	3,603	..	3,940	..	4,031	..	4,631

Sources: Energy, Mines and Resources Canada; Statistics Canada.
Note: As figures have been rounded, sums may not correspond to the totals indicated.
P Preliminary; nes Not elsewhere specified; .. Not available; (1) minus $1,000.

TABLE 2. REPORTED CONSUMPTION[1] OF MICA IN CANADA, 1980-85

	1980	1981	1982	1983	1984r	1985P
	(tonnes)					
Gypsum products	790	545	1 204	1 722	1 415	1 911
Paint and varnish	1 678	1 483	1 402	948	600	815
Rubber	24	54	30	52	41	36
Other products[2]	84	177	109	280	418	343
Total	2 576	2 259	2 745	3 002	2 474	3 105

[1] Reported from EMR survey on the consumption of non-metallic minerals by Canadian manufacturing plants. [2] Includes bearings and brake linings, well-drilling muds, foundries, chemicals and other miscellaneous products.
P Preliminary; r Revised.

TABLE 3. WORLD PRODUCTION[1] OF MICA (ALL VARIETIES) 1982-85

	1982	1983	1984	1985e	Remarks
	(tonnes)				
United States[2]	96 140	126 980	146 030	124 760	Muscovite, flake and scrap
U.S.S.R.e	48 070	48 980	48 980	49 890	All varieties
Indiae	21 540	19 050	19 070	19 470	Muscovite, exports and local consumption, sheet and flake
Korean Republic	20 350	14 400	24 430	14 970	Muscovite, coproduct of kaolin and feldspar, scrap
Canada[3]	11 000	12 000	12 500	14 000	Phlogopite, flake and ground
Spain	3 430	3 400	1 360	10 000	Muscovite, coproduct of kaolin
Francee	6 480	5 990	10 850	9 980	Muscovite, coproduct of kaolin
Brazil	1 080	3 460	3 600	3 540	Muscovite, sheet
Mexico	510	1 560	1 680	1 590	All varieties
Argentina	280	330	300	280	Muscovite, sheet and scrap
Madagascar	1 300	1 084	720	680	Phlogopite, sheet and scrap
Other countries	2 750	3 640	6 350	6 390	
World total[4]	212 930	240 874	276 050	246 250	

Source: U.S. Bureau of Mines.
[1] U.S. Bureau of Mines, Mica; Lawrence Davis, 1985. [2] Excluding the production of sericite estimated at 37 190 tonnes in 1985. [3] Shipments estimate. [4] In addition to these countries, Morocco, Taiwan, Zimbabwe, Finland, Romania, the People's Republic of China and Pakistan are other mica producers.
e Estimated.

TABLE 4. GROUND MICA[1] TRADE AND REPORTED CONSUMPTION IN CANADA 1970, 1975 AND 1980-86

	Imports	Reported Consumption
	(tonnes)	
1970	3 422	2 611
1975	5 111	3 718
1980	2 597	2 576
1981	3 133	2 259
1982	2 860	2 745
1983	2 790	3 002
1984^r	2 287	2 474
1985P	2 216	3 105
1986P	2 143	..

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Sheet and ground mica.

P Preliminary; ^{r} Revised; .. Not available.

Mineral Aggregates

D.H. STONEHOUSE

SUMMARY 1986

In the last quarter of 1985, a survey by the Conference Board of Canada identified optimism towards business investment in Canada. This was undoubtedly tempered by increased oil prices which followed but reflected in real increases of over 9 per cent in total non-residential building construction in 1986. With expected strengthening of oil prices in 1987, construction activity could show signs of further improvement. Heavy or engineering construction activity has remained relatively stable and is not much greater than 70 per cent of record levels reached in 1982. From a regional perspective, the non-residential building construction sector showed substantial increase in Ontario and Quebec, slight improvement in Atlantic Canada and a decrease in western Canada. Demand for mineral aggregates generally reflects the up and down trends in construction but the timing of that demand and the type of construction for which expenditures are made make direct relation between construction expenditures and production of mineral aggregate materials rather difficult. Total aggregate production over the past three years has been in excess of 300 million tonnes a year (tpy). Average unit prices have not changed greatly and continue to fluctuate widely from province to province depending upon the proximity of the resource base to the consuming centre. Housing starts, a fair indicator of construction materials demand, which were only 134,900 in 1984, the second lowest level since 1966, rose to 165,826 in 1985 and to 202,000 in 1986, while total construction expenditures are expected to approach $60 billion.

Many provinces continued programs both to identify and to assess their aggregate resource base and to project future market requirements. In some instances these programs have been undertaken as part of Mineral Development Agreements under the Economic and Regional Development Agreements (ERDA's) arranged between the federal and provincial governments. The constraints to development of aggregate properties have not lessened. Property owners do not want quarries or gravel pits nearby nor would they like to see the prices increase to compensate for greater hauling distances. An awareness of the importance of mineral aggregates to the construction industry has been heightened by an appreciation of the extent and rate of urban expansion and the realization that already large deposits of aggregate material have been made inaccessible by the growth of towns and cities or by legislation.

Of particular note is the development of the Ontario Government's new Planning Act and the importance given to mineral aggregates policy within the Act. Municipal plans will be required not only to protect existing pits and quarries but to identify and preserve presently untapped aggregate reserves for future development. Concern has been registered from agricultural and environmental interests that aggregates have been given greater priority than they deserve and that touted future shortages are both exaggerated and unfounded. The fact remains that sand, gravel and stone are nonrenewable resources which continue to be vital to the economy.

Until recently none of the principal lightweight aggregates (vermiculite, pumice and perlite) was mined in Canada. Imports, mainly from the United States, supplied the requirements for use in both lightweight concrete and gypsum products, for loose insulation applications and for horticultural uses. During 1983 Aurun Mines Ltd. developed a perlite property near Empire Valley, British Columbia. In each of the next two years about 1 000 t was produced for processing at a plant near Surrey, British Columbia. The company has continued to investigate markets and processing techniques through 1986.

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CANADIAN DEVELOPMENTS

Sand and Gravel

Sand and gravel deposits are widespread throughout Canada, and large producers have established "permanent" plants as close to major consuming centres as possible. In addition to large aggregate operations usually associated with some other phase of the construction industry such as a ready-mix plant or an asphalt plant, there are many small producers serving localized markets. These are often operated on a seasonal or part-time basis. Many larger operations are short-term, intermittently serving as a supply arm of a heavy construction company, and provide material for a given project. Provincial departments of highways operate regional or divisional quarries to supply roadbed material for new and repair work. Exploitation by such a large number of widely diversified groups not only makes control difficult, it also provides great obstacles to the collection of accurate data concerning both production and consumption of sand, gravel and stone.

Estimates have indicated that available sand and gravel supplies in some regions will be depleted by the 1990s. This could make outlying deposits not only attractive but necessary to the continued operation of the Canadian construction industry in certain areas. Predicted shortages could encourage exploitation of underwater deposits and could make underground mining of crushed stone attractive.

Crushed Stone

The large number of stone-producing operations in Canada precludes describing within this review individual plants or facilities. Many are part-time or seasonal operations, many are operated subsidiary to construction or manufacturing activities by establishments not classified to the stone industry, and some are operated directly by municipal or provincial government departments producing stone for their own direct use. Quarries removing solid rock by drilling, blasting and crushing are not likely to be operated for small, local needs as are gravel pits and are, therefore, usually operated by large companies associated with the construction industry. Depending on costs and availability, crushed stone competes with gravel and crushed gravel as an aggregate in concrete and asphalt, and as railway ballast and road metal. In these applications it is subject to the same physical and chemical testing procedures as the gravel and sand aggregates.

Quarrying operations that can supply high quality construction aggregates or high chemical quality stone for specified uses have been successful on both the east and west coasts where ocean-going barges or other large volume ocean transportation facilities have been used to reduce the unit transportation costs. Producers of high calcium limestone on Texada Island in British Columbia have supplied Vancouver and Washington state cement and lime producers with raw material for many years. Construction aggregate from the Strait of Canso area in Nova Scotia has been barged to many Atlantic Canada areas and during the last two years has been shipped as far as Houston, Texas in 50 000 to 60 000 t shiploads. Marketing techniques concentrate on aggregate-poor areas where demand is growing and alternate supplies are more expensive. Production and processing costs are kept low, by the fact that deposits being exploited are adjacent to deep water, and on-land trucking and conveying are kept to minimum.

Detailed information about the aggregates industries can be obtained through the individual provincial departments of mines or equivalent. Most provinces have accumulated data relative to occurrences of stone of all types and in many cases have published such studies. The federal government, through the Geological Survey of Canada, has also gathered and published a great number of geological papers pertaining to stone occurrences.

Lightweight Aggregates

Four categories generally used to classify the lightweight aggregates combine elements of source, processing methods and end-use. Natural lightweight aggregates include materials such as pumice, scoria, volcanic cinders and tuff. Manufactured lightweights are bloated or expanded products obtained by heating certain clays, shales and slates. Ultra-lightweights are made from natural mineral ores, such as perlite and vermiculite, which are expanded or exfoliated by the application of heat and used mainly as plaster aggregate or as loose insulation. Fly ash, which is obtained from the combustion of coal and coke and slag, which is obtained from metallurgical processes, are classed as by-product aggregates.

Perlite: Perlite is a variety of obsidian or glassy volcanic rock that contains 2 to 6 per cent of chemically combined water. When the crushed rock is heated rapidly to a suitable temperature (760°C to 980°C) it expands to between 4 and 20 times its original volume. Expanded material can be manufactured to weigh as little as 30 to 60 kg/m^3, with attention being given to preblending of feed to the kiln and retention time in the kiln.

In Canada, imported perlite is expanded and used mainly by gypsum products manufacturers in plaster products such as wallboard or drywall, and in fibre-perlite roof insulation board, where its value as a lightweight material is augmented by its fire-resistant qualities. It is also used as a loose insulation and as an insulating medium in concrete products. Perlite, vermiculite, and expanded shale and clay are becoming more widely used in agriculture as soil conditioners and fertilizer carriers.

Imports of crude perlite for consumption in Canada are from New Mexico and Colorado deposits, worked by such companies as Manville Corporation, United States Gypsum Company, United Perlite Corp. and Grefco, Inc.

Aurun Mines Ltd. has begun to produce perlite from a deposit near Empire Valley in British Columbia. During 1984 the company constructed a processing plant near Vancouver. Export markets are being investigated.

Pumice: Pumice is a cellular, glassy lava, the product of explosive volcanism, usually found near geologically-recent or active volcanoes. It is normally found as a loosely compacted mass composed of pieces ranging in size from large lumps to small particles. It is not the lightest of the lightweight aggregates, but when utilized as a concrete aggregate, particularly for the manufacture of concrete blocks, it exhibits strength, density and insulating values that have made it a preferred material.

In Canada, a number of concrete products manufacturers use pumice imported from Greece or from the northwestern United States, mainly in the manufacture of concrete blocks. A major use for pumice, as yet unexplored in Canada, has been in highway construction, where lightweight aggregate surfaces have been shown to have exceptional skid resistance.

Pumicite, distinguished from pumice by its finer size range (usually minus 100 mesh), is used in concretes mainly for its pozzolanic qualities. (A pozzolan is a siliceous material possessing no cementitious qualities until finely ground, in which form it will react with calcium hydroxide in the presence of moisture to form insoluble calcium silicates.)

Extensive beds of pumicite have been noted in Saskatchewan and British Columbia.

Vermiculite: The term vermiculite refers to a group of micaceous minerals, hydrous magnesium-aluminum silicates, that exhibit a characteristic lamellar structure and expand or exfoliate greatly upon being heated rapidly. Mining is normally by open-pit methods, and beneficiation techniques include the use of hammer mills, rod mills, classifiers, screens, dryers and cyclones. Exfoliating is done in oil- or gas-fired, vertical or inclined furnaces, usually close to the consuming facility to obviate the higher costs associated with shipping the much-bulkier expanded product. Required temperatures can vary from 1 100°C to 1 650°C depending on the type of furnace in use. A controlled time and temperature relation is critical in order to produce a product of minimum bulk density and good quality.

The expansion process has been improved technologically to enable production of various grades of expanded vermiculite as required. The uses to which the product is put depend on its low thermal conductivity, its fire-resistance and, more recently, on its lightweight qualities.

Canadian consumption is mainly as loose insulating material, with smaller amounts being used as aggregate in the manufacture of insulating plaster and concrete. The energy situation will undoubtedly result in greater use of insulation in both new construction and older buildings.

The major producer of vermiculite is the United States. The principal company supplying Canada's imports is W.R. Grace and Company, from operations at Libby, Montana and from the Enoree region of South Carolina. Canada also imports crude vermiculite from the Republic of South Africa, where Palabora Mining Co. Ltd. is the major producer. Minor amounts of vermiculite are produced in Argentina, Brazil, India, Kenya and Tanzania.

Vermiculite occurrences have been reported in British Columbia, and deposits near both Perth and Peterborough in Ontario have been investigated but, as yet, no commercial deposits have been developed in Canada.

Clay, shale and slag: Common clays and shale are used throughout Canada as raw material for the manufacture of lightweight aggregates. Although the Canadian industry began in the 1920s in Ontario, it did not evolve significantly until the 1950s when it grew in support of demands from the construction industry. The raw materials are usually quarried adjacent to the plant sites at which they are expanded. Clays receive little beneficiation other than drying before being introduced to the kiln in which they are heated. Shales are crushed and screened before burning.

In steelmaking, iron ore, coke and limestone flux are melted in a furnace. When the metallurgical process is completed, lime has combined with the silicates and aluminates of the ore and coke and formed a nonmetallic product (slag) which can be subjected to controlled cooling from the molten state to yield a porous, glassy material. Slag has many applications in the construction industry.

In July 1985, Reiss Lime Company of Canada, Limited announced plans for a $13 million slag cement project in northern Ontario. A slag granulation unit will be located at The Algoma Steel Corporation, Limited, Sault Ste. Marie steel works and a plant to grind slag granules for use as cement will be constructed at the Reiss Lime property at Spragge, Ontario, together with storage and handling facilities. Initial sales of slag cement will be directed at the northern Ontario mining industry where it will be used in mine backfill. The Spragg plant will have a capacity of 200 000 tpy.

Although Canada does not produce large amounts of fly ash, the technology of fly ash processing and utilization is well advanced. The largest single use for fly ash is as a cementitious material, in which application its pozzolanic qualities are utilized. Use of fly ash as a lightweight aggregate could become increasingly important. Ontario Hydro produces over 400 000 tpy of fly ash from three coal-fired stations. Experimentation continues toward successful utilization of this material.

PRICES

There are no standard prices for sand, gravel and crushed stone. In addition to supply-demand factors, prices are determined regionally, or even locally, by production and transportation costs, by the degree of processing required for a given end use and by the quantity of material required for a particular project. Increased land values, reduction of reserves and added rehabilitation expenditures should result in higher prices.

Prices for graded, washed and crushed sand, gravel and stone will show a slow but steady increase, based on greater property costs, more sophisticated operating techniques and equipment, pollution and environmental considerations, and higher labour and transportation costs.

USES

The principal uses for sand and gravel are in highway construction and as concrete aggregate. Individual home construction triggers the need for about 300 t of aggregate per unit while apartment construction requires only about 50 t per unit, according to an Ontario Ministry of Natural Resources study.

The construction industry utilizes 95 per cent of total stone output as crushed stone mainly as an aggregate in concrete and asphalt, in highway and railway construction and as heavy riprap for facing wharves and breakwaters. Specifications vary greatly, depending on the intended use, and many tests are required to determine the acceptability of aggregates for certain applications. Particle size distribution of aggregates, as assessed by grading tests or sieve analysis, affects the uniformity and workability of a concrete mix as well as the strength of the concrete, the density and strength of an asphalt mix, and the durability, strength and stability of the compacted mass when aggregates are used as fill or base-course material. Of importance also are tests to determine the presence of organic impurities or other deleterious material, the resistance of the aggregate to abrasion and to freeze-thaw cycles, the effects of thermal expansion, absorption, porosity, reactivity with associated materials and surface texture.

The use of sand and gravel as backfill in mines continues, along with increasing use of cement and mill tailings for this purpose. Abrasive sands, glass sand, foundry sands and filter sands are also produced.

The use of lightweight concrete in commercial and institutional projects has facilitated the construction of taller buildings and the use of longer clear spans in bridges and buildings. Additional advantages from the use of lightweight aggregates lie in the fact that they supply thermal and acoustical insulation, fire resistance, good freeze-thaw resistance, low water absorption and a degree of toughness to the concrete product. Disadvantages stem from the fact that in production of both manufactured and ultra-lightweight aggregates heat processing is required. As the cost of fuel increases, the competitiveness of these types will be reduced unless the insulation values more than offset the heat units consumed in processing.

Any lightweight material with acceptable physical and chemical characteristics could substitute for the mineral commodities generally used. The most significant substitute for vermiculite, for instance, is styrofoam or polyurethane, which offers insulating value and comparable strength. However, these materials are petroleum-based and higher fuel prices could limit their use. Mineral wool is a competitive insulation material but its manufacture requires a pyroprocessing stage, as does the production of perlite and vermiculite. Transportation costs for high-bulk, lightweight materials are high; those materials, such as perlite and vermiculite, that can be transported to a consuming centre prior to expansion, have obvious advantages.

There are as yet no Canadian Standards Association (CSA) specifications for the lightweight aggregates. Production and application are based on the American Society for Testing and Materials (ASTM) designations as follows: ASTM Designations C 332-66 - Lightweight Aggregates for Insulating Concrete; C 330-75a - Lightweight Aggregates for Structural Concrete; and C 331-69 - Lightweight Aggregates for Concrete Masonry Units.

OUTLOOK

The following indicators provide a positive outlook for building construction in Canada: housing starts are increasing, inflation is relatively low, interest rates have steadied and unemployment is decreasing. On a regional basis the construction outlook is fairly good in eastern Canada but less encouraging in the west where the effects of depressed world oil prices will likely mean less investment. The Canadian Construction Association predicts increases of 4.5 per cent in constant dollars through 1995 in the non-residential contract construction sector.

Urban expansion has greatly increased demand for sand and gravel in support of major construction. Paradoxically urban spread has not only tended to overrun operating pits and quarries, but has extended at times to areas containing mineral deposits, thereby precluding the use of these resources. Further complications have arisen in recent years as society has become increasingly aware of environmental problems and the need for planned land utilization. Municipal and regional zoning must be designed to determine and regulate the optimum utilization of land, but must not be designed to provide less than optimum resources utilization. Industry must locate its plants so as to minimize any adverse effects on the environment from their operations. Also, provision must be made for rehabilitation of pit and quarry sites in order to ensure the best sequential land use. The frequency with which small quarries and pits materialize to supply short-lived, local demands, leaving unsightly properties, has prompted action by municipal and provincial governments to control or to prohibit such activity.

Ideally, the exploitation of sand, gravel and stone deposits should be done as part of the total land-use planning package, such that excavations are designed to conform with a master plan of development and even to create new land forms. Inventories indicating the potential available reserves of sand, gravel and stone should be prerequisite to legislation regulating land use. Surveys to locate such resources are being carried out in many provinces in order to optimize their use and to choose the best possible distribution routes to consuming centres. It should be observed that controls and zoning can reduce reserves of these resources significantly.

On average, total aggregate consumption will rise in line with population increases, housing requirements and construction in general. Sand and gravel consumption will continue in competition with crushed stone and, in some applications, with lightweight aggregates. New reserves must be located, assessed and made part of any community development planning or regional zoning, with optimum land and resource utilization in mind.

TABLE 1. CANADA, TOTAL PRODUCTION OF STONE, 1984-86

	1984		1985		1986P	
	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)
By province						
Newfoundland	558	3,328	600	3,192	529	2,612
Nova Scotia	4 377	21,529	4 452	23,944	4 203	22,504
New Brunswick	2 036	10,341	2 394	12,168	2 030	11,074
Quebec	30 946	139,247	31 130	148,752	32 918	153,024
Ontario	33 992	160,847	37 180	168,768	41 883	189,892
Manitoba	2 120	11,927	4 155	15,787	3 466	13,100
Alberta	258	3,416	225	3,116	196	2,925
British Columbia	6 738	38,181	6 333	30,440	5 725	30,275
Northwest Territories	729	4,617	163	434	250	900
Canada	81 754	393,432	86 632	406,601	91 200	426,306
By use						
Building stone						
Rough	248	9,284	..	..	..	..
Monumental and ornamental stone	53	5,990	..	..	..	..
Other (flagstone, curbstone, paving blocks, etc.)	17	937	..	..	..	..
Chemical and metallurgical						
Cement plants, foreign	545	1,490	..	..	..	..
Lining, open-hearth furnaces	23	88	..	..	..	..
Flux in iron and steel furnaces	1 002	4,108	..	..	..	..
Flux in nonferrous smelters	325	2,856	..	..	..	..
Glass factories	196	3,093	..	..	..	..
Lime kilns, foreign	337	1,293	..	..	..	..
Pulp and paper mills	237	2,425	..	..	..	..
Sugar refineries	45	240	..	..	..	..
Other chemical uses	649	8,639	..	..	..	..
Pulverized stone						
Whiting (substitute)	30	1,810	..	..	..	..
Asphalt filler	123	724	..	..	..	..
Dusting, coal mines	1	18	..	..	..	..
Agricultural purposes and fertilizer plants	1 245	13,140	..	..	..	..
Other uses	156	6,460	..	..	..	..
Crushed stone for						
Manufacture of artificial stone	12	195	..	..	..	..
Roofing granules	313	22,187	..	..	..	..
Poultry grit	21	566	..	..	..	..
Stucco dash	12	426	..	..	..	..
Terrazzo chips	3	109	..	..	..	..
Rock wool	11	16	..	..	..	..
Rubble and riprap	2 339	11,736	..	..	..	..
Concrete aggregate	8 359	35,916	..	..	..	..
Asphalt aggregate	5 975	24,633	..	..	..	..
Road metal	25 059	92,871	..	..	..	..
Railroad ballast	7 389	44,362	..	..	..	..
Other uses	27 028	97,820	..	..	..	..
Total	81 754	393,432	..	..	..	..

P Preliminary; .. Not available.
Figures may not add due to rounding.

TABLE 2. CANADA, PRODUCTION OF SAND AND GRAVEL BY PROVINCE, 1984-86

	1984		1985		1986P	
	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)
Newfoundland	3 123	11,637	2 568	12,589	2 700	13,345
Prince Edward Island	271	805	588	1,917	475	1,700
Nova Scotia	8 180	20,925	8 829	23,958	8 325	25,150
New Brunswick	7 401	8,803	9 177	X	8 200	X
Quebec	35 189	66,353	32 520	X	26 023	X
Ontario	67 245	151,380	77 796	191,690	77 200	203,500
Manitoba	11 693	31,953	12 224	33,949	12 200	35,100
Saskatchewan	9 737	22,070	11 433	28,267	10 675	26,050
Alberta	45 494	105,001	49 237	121,668	48 400	108,000
British Columbia	35 103	85,973	43 774	107,670	41 900	106,600
Yukon and Northwest Territories	10 323	41,428	7 987	11,976	6 450	13,475
Canada	233 759	546,328	256 183	609,638	242 548	596,603

P Preliminary; X Confidential.
Figures may not add due to rounding.

TABLE 3. AVAILABLE DATA ON CONSUMPTION OF SAND AND GRAVEL, BY PROVINCE, 1983 AND 1984

		Atlantic Provinces	Quebec	Ontario	Western Provinces[1]	Canada
				(000 tonnes)		
Roads	1983	14 454	25 956	42 300	74 818	157 528
	1984	13 785	24 050	37 298	76 404	151 539
Concrete aggregate	1983	1 366	3 173	10 654	9 021	24 214
	1984	1 474	3 987	12 259	9 705	27 425
Asphalt aggregate	1983	1 846	2 793	3 837	7 662	16 138
	1984	1 799	3 160	4 167	5 072	14 198
Railroad ballast	1983	147	153	75	2 248	2 623
	1984	126	133	584	4 021	4 864
Mortar sand	1983	97	341	1 086	1 699	3 223
	1984	77	338	1 107	839	2 361
Backfill for mines	1983	1	189	767	14	971
	1984	120	218	870	342	1 551
Other fill	1983	795	4 058	8 197	7 307	20 357
	1984	1 242	2 903	8 916	7 210	20 271
Other uses	1983	328	343	1 399	6 282	8 352
	1984	351	400	2 045	8 755	11 551
Total sand and gravel	1983	19 035	37 006	68 316	109 051	233 408
	1984	18 974	35 189	67 246	112 348	233 759

[1] The western provinces include the Yukon and Northwest Territories.
Figures may not add due to rounding.

TABLE 4. CANADA, EXPORTS AND IMPORTS OF SAND AND GRAVEL AND CRUSHED STONE, 1983-86

	1983		1984		1985		Jan.-Sept. 1986	
	(tonnes)	($)	(tonnes)	($)	(tonnes)	($)	(tonnes)	($)
Exports								
Sand and gravel								
United States	83 931	328,000	108 926	551,000	234 883	921,000	217 703	832,000
South Africa	34	9,000	122	32,000	1 854	14,000	18	5,000
Algeria	103	10,000	146	14,000	-	-	-	-
France	49	4,000	590	12,000	65	11,000	98	32,000
St. Pierre and Miquelon	19	2,000	19	2,000	-	-	19	2,000
Other countries	11 497	79,000	6	2,000	4 988	33,000	79	14,000
Total	95 633	432,000	109 809	613,000	241 790	979,000	217 917	885,000
Crushed limestone								
United States	1 390 795	8,375,000	1 216 628	6,811,000	1 195 939	6,550,000	957 717	5,632,000
Other countries	-	-	46	4,000	-	-	338	1,000
Total	1 390 795	8,375,000	1 216 674	6,815,000	1 195 939	6,550,000	958 055	5,633,000
Imports								
Sand and gravel, nes								
United States	878 545	4,362,000	1 266 255	6,113,000	1 109 425	5,380,000	813 705	4,113,000
West Germany	36	6,000	715	3,000	846	3,000	135	2,000
Other countries	33	4,000	13	2,000	1 530	24,000	160	15,000
Total	878 614	4,372,000	1 266 983	6,118,000	1 111 801	5,408,000	814 000	4,130,000
Crushed limestone								
United States	1 799 861	8,447,000	1 944 045	9,666,000	2 071 651	10,889,000	1 745 996	9,708,000
Total	1 799 861	8,447,000	1 944 045	9,666,000	2 071 651	10,889,000	1 745 996	9,708,000
Crushed stone, nes								
United States	43 889	1,092,000	44 108	1,377,000	66 788	1,646,000	40 244	1,092,000
Italy	63	3,000	230	28,000	43	6,000	71	8,000
Other countries	34	10,000	76	2,000	195	38,000	35	4,000
Total	43 986	1,105,000	44 414	1,408,000	67 026	1,690,000	40 350	1,104,000

Source: Statistics Canada.
- Nil; nes Not elsewhere specified.

TABLE 5. LIGHTWEIGHT AGGREGATE PLANTS IN CANADA, 1985

Company	Location	Commodity	Remarks
Atlantic Provinces			
Annapolis Valley Peat Moss Company Limited	Berwick, N.S.	Perlite, Vermiculite	Processed mainly for use in horticulture.
Avon Aggregates Ltd.	Minto, N.B.	Expanded Shale	Processed for concrete products industry.
Quebec			
Armstrong World Industries Canada Ltd.	Gatineau	Perlite	Processed for use in ceiling tile manufacture.
Domtar Inc.	Montréal	Perlite, Vermiculite	Processed material purchased for use in gypsum plaster and wallboard at all company plants.
Miron Inc.	Montréal	Pumice	Purchased for concrete block manufacture.
Perlite Industries Inc.	Ville Saint-Pierre	Perlite	Processed for use in horticulture and as industrial filler.
V.I.L. Vermiculite Inc.	Lachine	Vermiculite	Processed for use in horticulture and as loose insulation.
Ontario			
Canadian Gypsum Company, Limited	Hagersville	Perlite	Processed for use in gypsum plaster.
National Slag Limited	Hamilton	Slag	Used in concrete blocks and as slag cement.
W.R. Grace & Co. of Canada Ltd.	St. Thomas	Vermiculite	Vermiculite processed for use in horticulture and as loose insulation.
	Ajax	Vermiculite, Perlite	Perlite processed for use in gypsum plaster and in horticulture.
Prairie Provinces			
Apex Aggregate	Saskatoon, Sask.	Expanded clay	Processed for concrete block manufacture.
Cindercrete Products Limited	Regina, Sask.	Expanded clay	Processed for concrete products industry.
Consolidated Concrete Limited	Calgary, Alta.	Expanded shale	Processed for concrete products industry.
	St. Albert, Alta.	Expanded clay	Processed for concrete products industry.
Genstar Corporation, Edcon Block Division	Edmonton, Alta.	Expanded clay	Processed for concrete block manufacture.
Kildonan Concrete Products Ltd.	Winnipeg, Man.	Expanded clay	Processed for concrete products industry.
W.R. Grace & Co. of Canada, Ltd.	Winnipeg, Man.	Vermiculite, Perlite	Perlite processed for use in gypsum plaster and in horticulture.
	Edmonton, Alta.	Vermiculite, Perlite	Vermiculite processed for use in horticulture and as loose insulation.
British Columbia			
Genstar Corporation	Vancouver	Pumice	Purchased for concrete block manufacture.
Aurun Mines Ltd.	Aldergrove	Perlite	

TABLE 6. CANADA, IMPORTED RAW MATERIALS PURCHASED, 1984 AND 1985

	1984		1985	
	(tonnes)	($)	(tonnes)	($)
Pumice, perlite and vermiculite[1]	42 232	5,617,752	35 399	4,715,061

Source: Company data.

[1] Combined to avoid disclosing confidential company data.

TABLE 7. CANADA, PRODUCTION OF LIGHTWEIGHT AGGREGATES, 1984 AND 1985

	1984		1985	
	(m^3)	($)	(m^3)	($)
From domestic raw materials				
Expanded clay, shale and slag	149 524	3,560,468	193 578	5,323,452
From imported crude materials				
Expanded perlite and exfoliated vermiculite[1]	398 462	15,659,737	310 837	13,046,059
Total	547 986	19,220,205	504 415	18,369,511

Source: Company data.

[1] Combined to avoid disclosing confidential company data.

TABLE 8. CANADA, CONSUMPTION OF SLAG, PERCENTAGE BY USE, 1983-85

Use	1983	1984	1985
Concrete block manufacture	27.0	28.0	28.0
Ready-mix concrete	2.0	1.0	1.0
Loose insulation	1.0	1.0	1.0
Slag cement	70.0	70.0	70.0

Source: Company data.

TABLE 9. CANADA, CONSUMPTION OF EXPANDED CLAY AND SHALE, PERCENTAGE BY USE, 1983-85

Use	1983	1984	1985
Concrete block manufacture	80.6	80.5[r]	78.2
Precast concrete manufacture	7.8	7.1[r]	5.1
Ready-mix concrete	6.5	7.2[r]	12.0
Horticulture and miscellaneous uses	5.1	5.2[r]	4.7

Source: Company data.

[r] Revised.

TABLE 10. CANADA, CONSUMPTION OF EXPANDED PERLITE, PERCENTAGE BY USE, 1983-85

Use	1983	1984	1985
Insulation			
in gypsum products	21.9	26.7	31.6
in other construction materials	28.0	27.1	37.7
Horticulture and agriculture	34.6	38.4	25.7
Loose insulation and miscellaneous uses	15.5	7.8	5.0

Source: Company data.

TABLE 11. CANADA, CONSUMPTION OF EXFOLIATED VERMICULITE, PERCENTAGE BY USE, 1983-85

Use	1983	1984	1985
Insulation			
loose	30.2	24.5	23.9
in concrete and concrete products	0.4	1.2	-
in gypsum products	0.5	0.7	-
Horticulture	46.3	56.7	64.3
Miscellaneous uses	22.6	16.9	11.8

Source: Company data.
- Nil.

TABLE 12. CANADA, VALUE OF CONSTRUCTION[1] BY TYPE, 1984-86

	1984	1985	1986
		($ millions)	
Building Construction			
Residential	16,647	18,750	21,177
Industrial	2,708	3,216	3,395
Commercial	7,129	8,201	8,563
Institutional	2,924	3,143	3,404
Other building	2,003	2,025	2,010
Total	31,411	35,335	38,549
Engineering Construction			
Marine	474	434	483
Highways, airport runways	4,276	4,648	4,514
Waterworks, sewage systems	2,170	2,148	2,237
Dams, irrigation	272	303	324
Electric power	3,664	3,494	3,491
Railway, telephones	2,724	2,728	2,677
Gas and oil facilities	8,552	9,178	8,580
Other engineering	3,031	3,131	2,967
Total	25,162	26,114	25,273
Total construction	56,574	61,449	63,822

Source: Statistics Canada.
[1] Actual expenditures 1984, preliminary actual 1985, intentions 1986.

TABLE 13. CANADA, VALUE OF CONSTRUCTION[1] BY PROVINCE, 1984-86

	1984			1985			1986		
	Building Construction	Engineering Construction	Total	Building Construction	Engineering Construction	Total	Building Construction	Engineering Construction	Total
					($000)				
Newfoundland	512,020	1,103,521	1,615,541	559,926	1,046,395	1,606,321	648,726	777,677	1,426,403
Nova Scotia	947,048	1,157,778	2,104,826	1,145,364	1,170,295	2,315,659	1,142,984	822,811	1,965,795
New Brunswick	735,008	465,074	1,200,082	795,548	483,805	1,279,353	849,490	413,322	1,262,812
Prince Edward Island	117,220	74,162	191,382	145,928	68,638	214,566	149,321	80,269	229,590
Quebec	7,714,033	4,065,606	11,779,639	8,773,335	3,812,658	12,585,993	9,271,680	3,796,029	13,067,709
Ontario	11,409,974	5,359,605	16,769,579	13,572,920	5,378,915	18,951,835	15,583,901	5,394,357	20,978,258
Manitoba	1,151,749	721,257	1,873,006	1,320,926	793,268	2,114,194	1,416,651	973,561	2,390,212
Saskatchewan	1,227,024	1,385,015	2,612,039	1,258,206	1,656,228	2,914,434	1,293,703	1,553,938	2,847,641
Alberta	3,299,989	6,230,580	9,530,569	3,435,866	7,273,787	10,709,653	3,876,910	7,947,462	11,824,372
British Columbia, Yukon and Northwest Territories	4,297,525	4,600,290	8,897,815	4,249,136	4,430,416	8,757,429	4,316,058	3,513,411	7,829,469
Canada	31,411,590	25,162,888	56,574,478	31,334,296	26,114,405	61,449,437	38,549,424	25,272,837	63,822,261

Source: Statistics Canada.

[1] Actual expenditures 1984, preliminary actual 1985, intentions 1986.

Molybdenum

D.G. FONG

Molybdenum supply in the western world, at about 73 600 t, matched demand in 1986. The increased industry concentration due to a reduction in the number of active companies, the greater market discipline exercised by the primary producers and the reintroduction of a producer price were the major factors for the gradual improvement in price and market stability.

The demand for molybdenum was strong in Europe during 1986, especially in the stainless and high speed steel sectors. However, this was more than offset by weaker markets in the United States and Japan. In Japan, a strong yen had a negative effect on its steel industry, including the specialty steel sector.

Molybdenum production in Canada increased by 60 per cent in 1986 to 11 500 t of contained molybdenum. This large increase was mainly due to the reopening of one large mine in 1986 and the continuation of full production at another that had been reopened late in 1985.

CANADIAN DEVELOPMENTS

Placer Development Limited resumed production at its Endako mine, British Columbia, in late August, following a prolonged shutdown. The mine had been closed since June 1982. Annual production was planned at 2 700 t of molybdenum per year, about one third of capacity. Placer decided to reopen the mine after the company received a five-year electric power rate reduction from the British Columbia government and the employees voted to decertify their labour unions.

Brenda Mines Ltd. produced a record output in 1986, due to the higher headgrade and better recovery rate. The mine was reopened in September 1985 following a nine-month shutdown and after being granted an electric power rate reduction by the provincial government. At its current operating rate, ore reserves at the present pit are expected to be mined out in the first quarter of 1989.

Cominco Ltd. and Lornex Mining Corporation Ltd. formed in July the joint venture Highland Valley Copper Corporation to manage the combined assets and operations of the Lornex and Valley Copper (Cominco) mines in the Highland Valley, British Columbia. Under the agreement, the two companies will participate equally in management, but they will split capital investments and cash generated from the operation on the basis of 55 per cent for Cominco and 45 per cent for Lornex.

Over an 18-month period, mining at the Lornex pit will gradually shift to the Cominco pit, which has a higher copper grade. However, due to the lower molybdenum grade of the Cominco orebody, molybdenum output is expected to be much lower than the 3 400 tpy normally produced from the Lornex ore.

Noranda Inc. discontinued molybdenum production at its Mine Gaspé, Quebec, in 1986. Noranda had completed a molybdenum recovery circuit at the Golden Giant Mine in Hemlo, Ontario, in 1985, but has not commissioned it yet. The company conducted further test work during 1986 on the recovery of molybdenum from Golden Giant ore that averages about 0.16 per cent MoS_2.

Ferromolybdenum is produced in Canada by Masterloy Products Limited of Ottawa. The company, which has a capcity of 1 700 t a year, has been producing ferromolybdenum on a toll-conversion basis. It also produces a variety of feroalloys using the thermite process. At the end of 1986, Masterloy was acquired by Applied Industrial Materials Corporation from International Minerals & Chemical Corporation, both of Illinois.

Moli Energy Limited was building a production plant at Maple Ridge, 48 km east of Vancouver, to produce lithium-molybdenum

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rechargeable batteries. This new line of products uses pure molybdenum disulphide (as cathode) and lithium (as anode) to make a new generation of dry cell batteries. The plant, scheduled for start-up in late summer 1987, will have an initial capacity of 2 million AA cells a year and will eventually rise to about 33 million cells after five years of operation. Moli Energy is 70 per cent owned by TDC Technology Development Corporation which in turn is 25 per cent owned by Teck Corporation.

WORLD DEVELOPMENTS

In the United States, the major producers trimmed their output during the second half of 1986 in order to restore balance in the western world supply and demand. AMAX Inc. made production cutbacks of about 38 per cent at its Colorado mines and thus reduced its 1986 output to an estimated 19 500 t of molybdenum. These two mines had been operating at 50 per cent capacity since 1984.

Cyprus Minerals Company closed its Thompson Creek, Idaho mine for the months of July and October to stay in line with the 6 350 t it had scheduled for 1986. Thompson Creek has a capacity of 9 070 t of molybdenum a year.

Cyprus Minerals also announced that it planned to reduce Thompson Creek production to 4 080 t in 1987, although operations at its other molybdenum mines will remain unchanged. The Bagdad and Sierrita mines in Arizona are scheduled to produce a combined output of approximately 5 440 t in 1987. Sierrita has a nominal capacity of 9 070 tpy, but produced only 3 630 t in 1986.

The Sierrita mine was acquired from Duval Corporation in March and, in late November, Cyprus Minerals was in the process of completing a deal to purchase Metec, Inc. The purchase of Metec, which produces molybdenum chemicals and other value-added products, will make Cyprus Minerals a fully integrated molybdenum producer.

In November, Molycorp, Inc. terminated development work at its Questa, N.M. mine and placed it on care-and-maintenance. Mining operations were shut down in March following the union's rejection of a company proposal for wage and benefit concessions to help reduce operating costs.

By-product molybdenum production in the United States will likely increase during the next two years as a result of the reopening of two major mines in 1986. Montana Resources Inc. resumed production in August at the Butte copper-molybdenum mine, formerly owned by Anaconda Minerals Company. Molybdenum output will be about 4 000 tpy. Kennecott Corporation resumed mining in October at its Bingham Canyon mine after a $US 400 million modernization program. The production of copper and molybdenum is scheduled to restart by mid-1987, with the initial output of molybdenum at 5 440 tpy. The mine has an annual capacity of 7 260 t. Bingham Canyon had been closed since March 1985.

Corporacion Nacional del Cobre de Chile (CODELCO-CHILE) was planning to expand its molybdenum treatment plant at the Chuquicamata mine to 19 500 tpy of molybdenum by 1990. In 1985, Chuquicamata produced 11 880 t out of CODELCO's total molybdenum output of 18 370 t. CODELCO's production in 1986 fell to 16 590 t as a result of lower molybdenum grades.

China became a more important factor in western molybdenum markets during 1986. The country has been increasing its molybdenum exports to European markets, especially to the Eastern Bloc, which was was one of the reasons for a decline in western exports to these countries. China's presence as a source of supply is expected to expand further in 1987, due to its emphasis on exports.

China was building a molybdenum roaster in the province of Shanxi in northern China. The new plant, reported to have a designed capacity of 4 540 tpy of contained molybdenum, is expected to come on stream at the end of 1987.

The Government of Japan instituted a joint government-industry stockpile programme in 1983 for seven special and rare metals, including molybdenum. The objective was to insure a 60-day supply by 1987. However, due to budgetary constraints, the target date was revised to 1993 and a near-term objective was set for a 36-day supply in 1986. At year-end, the stockpile was a 23-day supply.

USES

Molybdenum is used in a wide range of products as an alloy additive, a chemical compound, a pure metal and as a lubricant.

Approximately 90 per cent of all molybdenum consumed in the western world is used in metallurgical applications including steel, ferrous castings, special alloys, and pure molybdenum metal. The remaining 10 per cent is used in non-metallurgical applications such as chemicals, catalysts and lubricants.

As an alloying additive in steel, molybdenum imparts hardenability, strength, toughness and resistance to corrosion and abrasion. Tool steels, stainless steels, high-strength steels, heat resisting steels and a wide range of alloy steels are important consumers of molybdenum. Depending on type and specification, molybdenum is added in amounts ranging from less than 0.1 per cent to nearly 10 per cent. Molybdenum can be added as a sole agent but, more often, it is used in combination with other additive metals.

Molybdenum is an important alloying element in most types of tool steels. Among the tool steel additives, molybdenum and tungsten both promote red hardness and increase wear resistance in high speed steels. The performance of these steels is proportional to the percentage of the elements. However, molybdenum produces more carbide than tungsten per unit weight added, and thus can replace tungsten at a rate of almost one to two. For some hot work tool steels and high speed steels, the molybdenum content can be as high as 10 per cent.

Additions of molybdenum to austenitic and ferritic stainless steels enhance resistance to corrosive acids and brines. These steels are finding increasing use in heat exchangers for severe chemical environments, seawater condenser tubings, caustic evaporators, and heat resisting steels operating under stress and high temperatures.

In high-strength low-alloy steels, the addition of molybdenum increases the yield and tensile strength, and improves toughness and weldability. Steels with these properties are especially useful in structural applications and in Arctic-grade large-diameter pipelines. The consumption intensity of molybdenum in pipeline steels has declined, especially in Japan and western Europe where pipeline manufacturers have switched to non-molybdenum steels, even for the Arctic-grade pipelines. This increase in substitution to other ferroalloy additives was brought about mainly by the high prices and short supply of molybdenum in the late-1970s.

Molybdenum is an important constituent of many high performance alloys that are extremely resistant to heat, corrosion and wear. These alloys are used extensively in aerospace components, chemical processing plants, and high temperature furnace and foundry parts.

Molybdenum compounds are used as catalysts in the petroleum refining and chemical processing industries. Molybdenum orange, an important molybdenum pigment, is used in printing inks, dyes and corrosion resistant primers. Pure molybdenum disulphide is an excellent dry lubricant and is used as an oil additive. The lamellar structure of molybdenum disulphide helps reduce friction and thus prolongs engine life. In recent years, non-metallurgical applications have been experiencing a faster growth rate than other uses.

New uses have recently been developed for molybdenum in a new generation of batteries. The lithium-molybdenum battery is found to have more energy and power per cell volume than the conventional nickel-cadmium or alkaline units. It is also superior in terms of rechargeability, charge retention and storage temperature range. Because of the relatively high price, its main market is expected to be original equipment manufacturers which install batteries in such items as cameras, photoflashes, portable televisions and computers, military communications equipment and any other applications where light weight, charge retention and power density are important factors.

PRICES

The Metals Week quotation of the traders' market rose from a low range of $US 5.62-5.84 per kg of molybdenum oxide at the beginning of the year to a high of $US 6.99-7.17 in October. At year-end, however, it slipped to $US 6.72-6.83 as demand weakened. Producer prices, which were reintroduced in March after an absence of two years, were initially set at $US 7.05 and raised to $US 7.61 in October.

OUTLOOK

The molybdenum market is expected to remain stable in the near term, with supply and demand in close balance. The recent strong demand in Europe, especially in West Germany, will likely continue at least for the first half of 1987, while the Japanese market will deteriorate because of the strong yen. However, the falling U.S. dollar could have some positive effect on U.S. industrial production, resulting in an increase in capital investments and molybdenum consumption. Western world production is forecast to fall marginally in 1987 to 72 000 t.

The molybdenum producers have taken a number of positive steps during the last two years to place the industry back on a firm footing. These include the reduction of capacity through the permanent closure of a number of mines, the reintroduction of producer prices, the implementation of cost-reduction programs, and an improvement in supply discipline. However, projected consumption, estimated to rise less than 2 per cent per year until the end of the decade, will remain well below production capacity. Accordingly, the mining industry, including by-product producers, will have to exercise strict supply discipline to maintain the current market stability.

The reintroduction of the producer price in 1986 was a major step towards stabilizing the market. Prices could improve marginally during the next two years but they are more likely to remain at the current level. A higher price would encourage production from some of the idled mines.

Molybdenum inventories, estimated at eight months of consumption, are not expected to change in 1987. Most of these inventories are held by major producers, which are strongly motivated to hold inventories while the market is weak.

The long term outlook for molybdenum indicates market stability, dependable supply and relatively low prices. Molybdenum is expected to be very competitive compared with many of its substitutes.

A speaker for Cyprus Minerals Company at the Nickel/Molybdenum Conference held in Nice, France in December 1986, recommended the formation of a market-oriented molybdenum research association. He pointed out the need for improved statistics, particularly on consumption and stocks, and new product development that such an organization could undertake. Reports on the meeting stated that the formation of such an association should help to promote applications, defend existing markets, and contribute to a better understanding of the worldwide supply and demand situation.

PRICES

Prices in $US per kilogram of contained molybdenum, f.o.b. shipping point unless otherwise indicated, December 31.

	1985	1986
	($)	
By-product concentrates (MoS_2)	5.07	6.17-6.28
Molybic oxide (MoO_3) in cans	..	7.61
Producer list price		
Dealer oxide (MoO_3) in cans; min. 57% Mo	5.62-5.84	6.81-7.05
Ferromolybdenum[2] Dealer export (fas port)	7.14-7.28	8.05-8.16

Source: Metals Week.

[1] Price quotation of AMAX and Cyprus Minerals. [2] Price based on molybdenum content.

.. Not available; fas Free alongside ship.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
CANADA					
32900-1	Molybdenum ores and concentrates	free	free	free	free
33505-1	Molybdenum oxides	10.0	12.8	25.0	8.5
35120-1	Molybdenum metal in powder, pellets, scrap, ingots, sheets, strips, plates, bars, rods, tubing or wire, for use in Canadian manufactures	free	free	25.0	free
37506-1	Ferromolybdenum	free	4.2	5.0	free
92847-1	Molybdates	9.9	9.9	25.0	6.5
	Temporary reduction, June 3, 1980 to June 30, 1987	free			free
92856-1	Molybdenum carbides	1.9	1.9	25.0	1.0
	Temporary reduction, June 3, 1980 to December 31, 1987	free			free
MFN Reductions under GATT (effective January 1 of year given)			1986	1987	
			(%)		
33505-1			12.8	12.5	
37506-1			4.2	4.0	
92847-1			9.9	9.2	
92856-1			1.9	free	
UNITED STATES					
417.28	Ammonium molybdate		4.5	4.3	
418.26	Calcium molybdate		4.7	4.7	
419.60	Molybdenum compounds		3.3	3.2	
421.10	Sodium molybdate		3.9	3.7	
423.88	Mixtures of two or more inorganic compounds: in chief value of molybdenum		2.9	2.8	
601.33	Molybdenum ore (per lb. on Mo content)		9.4¢	9.0¢	
606.31	Ferromolybdenum		4.9	4.5	
628.70	Molybdenum metal, waste and scrap		6.6	6.0	
628.72	Molybdenum metal, unwrought		6.7¢/lb. on Mo content + 2.0	6.3¢/lb. on Mo content + 1.9	
628.74	Molybdenum metal, wrought		7.3	6.6	

EUROPEAN ECONOMIC COMMUNITY (MFN)		1986	Base Rate	Concession Rate
			(%)	
26.01	Molybdenum ores and concentrates	free		
28.28	Molybdenum oxides and hydroxides	5.3	8.0	5.3
28.47	Molybdates	6.6	11.2	6.6
28.56	Molybdenum carbides	8	9.6	8.0
73.02	Ferromolybdenum	4.9	7.0	4.9
81.02	Molybdenum, unwrought or wrought, and articles thereof:			
	A. Unwrought (including bars not further prepared than sintered and powders); waste and scrap:	5		
	I. Powders			
	II. Other			
	B. Bars (other than bars not further prepared than sintered), rods, angles, shapes, sections, wire, filaments, plates, sheets, strip and foil	8		
	C. Other	10		
JAPAN (MFN)				
26.01	Molybdenum ores and concentrates			
	A. Quota	free		
	B. Other	0.9	7.5	free
28.28	Molybdenum trioxide	3.9	5.0	3.7
28.47	Molybdates	5.3	7.5	4.9
28.56	Molybdenum carbides	3.9	5.0	3.7
73.02	Ferromolybdenum	3.9	7.5	4.9
81.02	Molybdenum metal			
	A. Unwrought, powders and flakes	5.2	5.0	3.7
	B. Waste and scrap	5.2	5.0	3.7
	C. Other	3.9	7.5	4.9

Sources: The Customs Tariff, 1986, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated (1986), USITC publication 1775; U.S. Federal Register, Vol. 44, No. 241; Official Journal of the European Communities, Vol. 28, No. L331, 1986; Customs Tariff Schedules of Japan, 1986.

TABLE 1. CANADA, MOLYBDENUM PRODUCTION AND TRADE, 1984-86, AND CONSUMPTION, 1983-85

	1984		1985		1986P	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Production (shipments)[1]						
British Columbia	11 420	104,774	7 526	71,099	12 514	110,413
Quebec	136	1,384	326	3,260	400	3,529
Total	11 556	106,158	7 852	74,359	12 914	113,942
					(Jan.-Sept.)	
Exports						
Molybdenum in ores, concentrates and scrap[2]						
Belgium-Luxembourg	1 858	16,250,617	1 208	9,731,539	3 278	27,589,409
Japan	2 279	26,809,303	1 004	10,963,991	1 646	15,160,546
United Kingdom	963	8,821,210	547	4,970,596	768	5,938,866
United States	405	3,490,552	470	4,391,585	569	5,667,485
West Germany	1 429	11,932,703	1 015	6,457,018	784	4,352,997
Netherlands	1 165	10,670,839	766	6,633,846	542	4,069,125
Chile	699	6,576,405	547	5,431,578	461	3,267,531
France	0	0	0	0	234	1,782,602
South Korea	8	71,206	55	512,012	85	604,923
Australia	59	711,797	25	451,159	11	226,706
Argentina	0	1,245	0	0	0	0
Spain	3	67,800	0	0	0	0
India	14	180,046	0	0	0	0
Philippines	7	140,776	0	0	0	0
Total	8 889	85,724,499	5 637	49,543,324	8 378	68,660,190
Imports						
Molybdic oxide and hydroxides	238	2,428	187	1,878	162	1,622
Molybdenum in ores and concentrates (Mo content)	329	2,782	577	4,517	1 079	7,654
Ferromolybdenum alloys	186	2,081	274	2,796	269	2,292

	1983	1984	1985
	(kilograms)	(kilograms)	(kilograms)
Consumption (Mo content)			
Addition agents	508 664r	676 957	706 208
Electrical and electronics	2 009	2 148	775
Other uses[3]	44 494r	57 559	65 318
Total	555 167r	736 664	772 301

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Producers' shipments (Mo content of molybdenum concentrates, molybdic oxide and ferromolybdenum). [2] Includes molybdenite and molybdic oxide in ores and concentrates. [3] Alloy, pigment and ceramics.
P Preliminary; r Revised; .. Not available.

TABLE 2. CANADA, MOLYBDENUM PRODUCTION, TRADE AND CONSUMPTION, 1970, 1975 AND 1977-86

	Production[1]	Exports[2]	Imports: Molybdic oxide[3]	Imports: Ferro-molybdenum[4]	Consumption[5]
	(kilograms)				
1970	15 318 593	13 763 800	33 500	29 619	1 036 940
1975	13 323 144	15 710 300	56 400	269 281	1 436 883
1977	16 567 555	15 326 100	192 100	74 330	1 149 736
1978	13 943 405	13 421 000	329 500	55 294	1 268 640
1979	11 174 586	11 481 900	335 900	153 945	1 249 944
1980	11 889 000	14 584 500	361 700	53 618	1 055 107
1981	12 850 000	13 664 000	423 000	36 069	1 314 584r
1982	13 961 000	17 444 000	193 000	6 840	672 118r
1983	10 194 000	11 284 000	141 000	34 000	555 167r
1984	11 556 777	8 896 000	238 000	186 000	736 664
1985	7 852 000	5 637 000	186 000	274 000e	772 301
1986P	12 914 000	11 170 000e	..	..	..

Sources: Energy, Mines and Resources Canada; Statistics Canada; except where noted.
1 Producers' shipments (Mo content of molybdenum concentrates, oxide and ferromolybdenum). 2 Mo content, oxides, ores and concentrates. 3 Gross weight. 4 United States exports to Canada, reported by the U.S. Bureau of Commerce, Exports of Domestic and Foreign Merchandise (Report 410), over 50 per cent molybdenum. 5 Mo content of molybdenum products reported by consumers.
P Preliminary; r Revised; e Estimated; .. Not available.

TABLE 3. WORLD PRODUCTION OF MOLYBDENUM IN ORES AND CONCENTRATES, 1984-86

Country	1984	1985	1986e
	(tonnes Mo content)		
United States	47 021	48 988	38 280
Canada	8 473	7 188	11 500
Chile	16 780	18 400	16 590
U.S.S.R.e	11 200	11 200	11 200
People's Republic of Chinae	2 000	6 800	9 070
Peru	2 629	3 800	3 200
Republic of Koreae	142	300	300
Bulgariae	330	330	330
Japane	97	120	100
Finlande	218	200	200
Mexico	5 865	4 535	3 630
Mongoliae	960	1 000	1 000
Total	63 054	102 861	95 400

Sources: Energy, Mines and Resources Canada; U.S. Bureau of Mines, Minerals Yearbook, Preprint, 1984; U.S. Bureau of Mines, Mineral Commodity Summaries, 1985; Intermet Third Quarterly Molybdenum Report, 1985, Santiago, Chile.
e Estimated.

TABLE 4. PRINCIPAL MOLYBDENUM PRODUCERS IN THE WESTERN WORLD, 1986

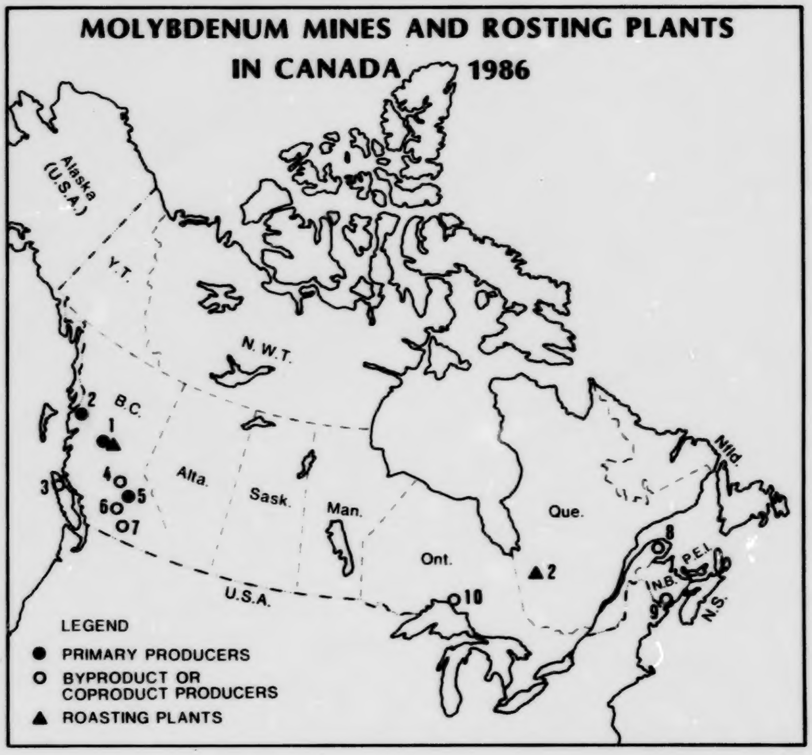
Company	Country	Mine ProductionP (000 tpy Mo)
AMAX Inc.	United States	19 500
Corporacion Nacional del Cobre de Chile (CODELCO-CHILE)	Chile	16 590
Cyprus Minerals Company	United States	11 800
Noranda Inc.	Canada	4 540
Lornex Mining Corporation Ltd.	Canada	3 400
Mexicana de Cobre, S.A.	Mexico	3 200
Kennecott Minerals Company	United States	..
Southern Peru Copper Corporation	Peru	3 200
Newmont Mining Corporation	United States	2 270
Montana Resources Inc.	United States	1 800
Utah Mines Ltd.	Canada	1 580
Molycorp, Inc.	United States	1 360
Placer Development Limited	Canada	1 130
Total		71 270

P Preliminary; .. Not available.

TABLE 5. CANADA, MINE PRODUCTION, 1985

Company and Mine Name	Location	Type of Producer	Mill Capacity (tpd)	Ore Milled		Concentrates Produced		
				Tonnes	Grade (% Mo)	Tonnes	Grade (% Mo)	Contained Mo (tonnes)
Amax of Canada Limited Kitsault Mine	Alice Arm B.C.	Primary	10 886	-	-	-	-	-
Brenda Mines Ltd.	Peachland, B.C.	Co-product	27 200	3 006 313	0.047	2 204	55.56	1 224
Gibraltar Mines Limited	McLeese Lake, B.C.	By-product	37 195	13 400 933	0.013	1 341	53.04	711
Highmont Mining Corporation	Highland Valley, B.C.	Co-product	22 680	-	-	-	-	-
Lornex Mining Corporation Ltd.,	Highland Valley, B.C.	By-product	72 575	29 214 991	0.016	6 372	54.05	3 444
Noranda Inc., Boss Mountain Division	Williams Lake, B.C.	Primary	2 631	-	-	-	-	-
Mines Gaspé Division Needle Mountain and Copper Mountain	Holland Township Gaspé, Que.	By-product	32 800	1 065 328	0.043	637	51.23	326
Placer Development Limited, Endako Mine	Endako, B.C.	Primary	29 937	-	-	-	-	-
Utah Mines Ltd., Island Copper mine	Port Hardy, B.C.	By-product	38 100	16 506 367	0.015	3 195	46.41	1 483
Total								7 188

Sources: Energy, Mines and Resources Canada; Company annual reports.
- Nil.


MOLYBDENUM MINES AND ROSTING PLANTS
IN CANADA 1986
Alaska (U.S.A.)
Y.T.
N.W.T.
B.C.
Alta.
Sask.
Man.
Ont.
Que.
Nfld.
P.E.I.
N.B.
N.S.
U.S.A.
1
2
3
4
5
6
7
8
9
10
2
LEGEND
● PRIMARY PRODUCERS
○ BYPRODUCT OR COPRODUCT PRODUCERS
▲ ROASTING PLANTS

Mines

1. Placer Development Limited (Endako Mine)
2. Amax of Canada Limited (Kitsault Mine)
3. Utah Mines Ltd. (Island Copper Mine)
4. Gibraltar Mines Limited
5. Noranda Inc. (Boss Mountain Division)
6. Highland Valley Copper Corporation
   Highmont Mining Corporation
7. Brenda Mines Ltd.
8. Noranda Inc. (Gaspé Division)
9. Mount Pleasant Resources Inc.
10. Noranda Inc. (Golden Giant Mine)

Roasting Plants

1. Placer Development Limited (Endako Mine)
2. Eldorado Gold Mines Inc. (Duparquet)

Nepheline Syenite and Feldspar

M.A. BOUCHER

SUMMARY

The glass industry is the principal consumer of nepheline syenite and feldspar. In 1986, strong competition from plastics, aluminum and paper continued and resulted in more container glass plant closures in North America. During the past two years, however, closures have considerably slowed down and most remaining plants are reported to be operating at near capacity. In Canada, consumption by the glass industry also declined while consumption by the glass fibre industry was almost flat. Demand for finer grade materials for uses such as ceramics, fillers and extenders was strong although tonnages are small compared to the glass industry.

Published prices increased for the first time since 1984. Ceramic and filler extender grade materials registered the most important increases.

CANADIAN DEVELOPMENTS

Production

Nepheline syenite is produced in Ontario by Indusmin Limited, a subsidiary of Falconbridge Limited. The company operates two mines and two concentrating plants with an estimated combined production capacity of 800 000 tpy of finished products. Nepheline syenite is mined from two adjacent deposits located on Blue Mountain in Methuen Township, Peterborough County, 175 km northeast of Toronto. The two plants operated at 60 per cent of capacity in 1986. The nepheline syenite is upgraded to low-iron and high-iron glass grades, and to ceramic grades by primary and secondary crushing, drying, screening, high-intensity magnetic separation and pebble milling. For ultrafine grades (for use as filler in paints, plastics, etc.), the process uses air classification.

Feldspar is not produced on a large commercial scale in Canada. However, a potential producer is Bearcat Explorations Ltd. of Calgary.

Bearcat Explorations Ltd. is developing a pegmatite in southeastern British Columbia for the production of several industrial commodities. The pegmatite is composed of approximately 65 per cent feldspar, 25-30 per cent quartz, 5-8 per cent muscovite and 1 per cent accessory minerals. The unit outcrops for about 4 km in length and 1.5 km in width.

The objective is to produce a feldspathic product suitable for the glass, fiberglass and ceramic industry. Mica will be supplied to the drywall cement, paint and drilling mud industry, while quartz could be used in glassmaking and other applications.

Metallurgical testing is being conducted by the North Carolina State Research Laboratories. Results were reported to be very favourable.

Market studies have been conducted and a feasibility study is proposed for open-pit mining and strip mining. Production capacity of the plant still remains to be determined but production is expected to start sometime in 1987.

Tantalum Mining Corporation of Canada Limited (TANCO) of Bernic Lake, Manitoba reported that it was investigating the possibility of recovering feldspar as a by-product of its spodumene operation.

The feldspar which is rich in rubidium (1.3 per cent Rb_2O) and high in potassium (9.5 per cent K_2O) would be particularly in demand for the manufacture of high-voltage electrical insulators that require 15 to 50 per cent K-feldspar by weight, but also for glass and other ceramic products. Some 27 000 t of feldspar could be produced annually.

CONSUMPTION

The glass and glass fibre industries account for some 60 per cent of nepheline syenite consumption in Canada, while insulation and ceramic products account for about 17 per cent each.

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Consumption of nepheline syenite in Canada by glass producers continued to be negatively influenced by the use of plastics, paper and aluminum, by increased recycling of glass waste, and by the development of thinner glass containers. Although growth in filler and extender pigment applications is expected to continue at an increasing rate, tonnages of nepheline syenite consumption will remain small for many years.

The major consumers of nepheline syenite in Canada are: Domglas Inc., Consumers Packaging Inc., Fiberglas Canada Inc., American Standard Inc., and Crane Canada Inc.

Important consumers of feldspar are: Crane Canada Inc.; Electro Porcelain Co. Ltd.; Hamilton Porcelain Ltd.; JM Asbestos Inc.; and Cegelec Industries Inc.

TRADE

Canada has a large trade surplus with the United States. While exports of nepheline syenite to the United States averaged 315 000 tpy from 1984 to 1986, imports of feldspar from the United States averaged only about 2 500 tpy. Nearly all feldspar imported into Canada comes from North Carolina.

Market areas for North American producers of feldspar, nepheline syenite and aplite

Market area	Material
Central and eastern Canada and north central United States	nepheline syenite
Northeast United States	feldspar
East central United States	aplite
Southeast and south central United States	feldspar
Southwest United States	feldspar-silica sand, feldspar

PRICES

The unit value of production (shipments) of nepheline syenite increased by 10 per cent in 1986 over 1985 and the unit value of exports to the United States increased by 12 per cent in 1986 (based on nine-month figures).

Listed prices for nepheline syenite in 1986 ranged from a low of $US 23.69 per t for sand to a high of $US 98.08 per t for filler and extender grades.

USES

Nepheline syenite is preferred to feldspar as a source of alumina and alkalis for glass manufacture. Its use results in more rapid melting of the batch at lower temperatures than with feldspar, thus reducing fuel consumption, lengthening the life of furnace refractories, and improving the yield and quality of glass. Other industrial uses for nepheline syenite include ceramic glazes, enamels, fiberglass and fillers in paints, papers, plastics and foam rubber.

Feldspar is the name of a group of minerals consisting of aluminum silicates of potassium, sodium and calcium. It is used in glassmaking as a source of alumina and alkalis, in ceramic bodies and glazes, in cleaning compounds as a moderate abrasive and as a flux coating on welding rods. High calcium feldspars, such as labradorite, and feldspar-rich rocks, such as anorthosite, find limited use as building stones and for other decorative purposes. Potash feldspar is an essential ingredient in the manufacture of high-voltage porcelain insulators. Dental spar, which is used in the manufacture of artificial teeth, is a pure white potash

OUTLOOK

Efforts in marketing could result in improved sales of nepheline syenite in 1987, particularly in Europe, but also in the United States.

Since nepheline syenite competes with feldspar and aplite produced in the United States in many applications, rail deregulation in the United States is expected to negatively affect Canada's competitiveness in that country.

Increased recycling of glass in North America is expected to continue; thus, consumption of nepheline syenite and feldspar should also decrease.

On the positive side, research programmes have been established to develop a strong and light weight glass which would be competitive with other container materials; although the new product would require less raw materials, the additional demand may more than offset the reduction in unit consumption of raw materials.

Batch briquetting of raw materials that melt at shortened cycles and lower temperatures is still not widely used. If successful, the new process is expected to help reduce energy costs in glass container manufacturing and improve their competitiveness.

Innovative marketing strategies such as in the field of packaging is one area where the glass container industry could focus its efforts in order to become more competitive.

PRICES OF FELDSPAR AND NEPHELINE SYENITE IN U.S. CURRENCY

	1984	1985	1986
		($/tonne)	
FELDSPAR			
Ceramic grade, bulk			
f.o.b. Spruce Pine, N.C., 170-250 mesh	48.50	48.50	48.50
f.o.b. Monticello, Ga, 200 mesh, high potash	81.00	81.00	81.00
f.o.b. Middleton, Conn., -200 mesh	58.68	58.68	58.68
Glass grade, bulk			
f.o.b. Spruce Pine, N.C., 97.8% + 200 mesh	32.34	32.34	33.89
f.o.b. Middleton, Conn., 96% + 200 mesh	42.98	42.98	42.98
f.o.b. Monticello, Ga, 200 mesh, high potash	59.50	59.50	59.50
NEPHELINE SYENITE			
Canadian, CL-car lots TL-truck lots			
Glass grade, 30 mesh, bulk CL/TL, low iron	28.65-31.40	28.65-31.40	30.85-33.61
Glass grade, 30 mesh, bulk CL/TL, high iron	22.04-25.62	22.04-25.62	23.69-27.24
Ceramic grade, 200 mesh, bagged 10-ton lots	60.60-62.81	60.60-62.81	70.53-72.73
Filler/extender grade	73.83-93.67	73.83-93.67	93.67-98.08

Source: Industrial Minerals, December 1984, 1985, 1986.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(per cent)		
CANADA					
29600-1	Feldspar, crude	free	free	free	free
29625-1	Feldspar, ground but not further manufactured	free	5.8	30	free
29640-1	Ground feldspar for use in Canadian manufactures	free	free	30	free
	Nepheline syenite	free	free	free	free
MFN Reductions under GATT (effective January 1 of year given)			1986	1987	
			(per cent)		
29625-1			5.8	5.5	
UNITED STATES (MFN)					
522.31	Crude feldspar		free		
522.41	Feldspar, crushed, ground or pulverized		2.9	2.8	
522.33	Crude nepheline syenite		free		
522.43	Nepheline syenite, crushed, ground or pulverized		free		

Sources: The Customs Tariff, 1986 Revenue Canada, Customs and Excise; Tariff Schedules of the United States, Annotated 1986, USITC Publication 1775. U.S. Federal Register, Vol. 44, No. 241.

TABLE 1. CANADA, NEPHELINE SYENITE PRODUCTION, EXPORTS AND CONSUMPTION, 1983-86

	1983		1984		1985		1986P	
	(tonnes)	($)	(tonnes)	($)	(tonnes)	($)	(tonnes)	($)
Production (shipments)	523 249	18,130,692	520 640	17,866,091	467 186	17,897,642	485 259	20,413,477
							(Jan.-Sept.)	
Exports								
United States	345 245	13,469,000	334 349	13,689,299	314 092	14,030,751	226 401	11,350,177
Netherlands	20 995	1,019,000	21 830	959,616	17 230	744,763	19 037	1,135,493
Italy	8 614	658,000	10 482	823,460	6 041	467,534	5 450	487,873
United Kingdom	8 926	472,000	5 426	322,467	6 132	319,914	320	43,675
Australia	8 943	294,000	9 933	357,703	1 129	90,328	4 997	327,430
Spain	1 927	105,000	897	63,238	2 294	116,727	897	94,889
Other countries	3 649	293,000	4 149	413,699	4 108	530,453	3 365	430,014
Total	398 299	16,310,000	387 066	16,629,480	351 026	16,300,470	260 467	13,869,551
Consumption^{1}								
Glass and glass products	54 127	..	55 218	..	43 820	..	..	..
Glass-fibre wool and glass fibre	16 331^{r}	..	15 812	..	17 013	..	..	..
Ceramic products	16 571	..	12 916	..	12 900	..	..	..
Paints	6 062^{r}	..	5 843	..	5 924	..	..	..
Others^{2}	1 543	..	1 766	..	1 873	..	..	..
Total	94 634	..	91 555	..	81 530	..	..	..

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Available data, as reported by consumers. [2] Includes frits and enamel, plastics, rubber products, heavy clay products, paper and paper products, and other minor uses.

P Preliminary; .. Not available; ^{r} Revised.

TABLE 2. CANADA, NEPHELINE SYENITE PRODUCTION AND EXPORTS, 1970, 1975 AND 1979-85

	Production[1]	Exports
	(tonnes)	
1970	454 110	351 940
1975	468 427	356 629
1979	605 699	471 056
1980	600 000	448 468
1981	588 000	476 281
1982	550 480	414 788
1983	523 249	398 299
1984	520 640	387 069
1985	467 186	351 026

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Producers' shipments.

TABLE 4. CANADA, CONSUMPTION AND VALUE OF IMPORTS OF CRUDE OR GROUND FELDSPAR, 1975 AND 1979-85

	Imports	Consumption
	($)	(tonnes)
1975	..	5 630
1979	501,000	4 588
1980	385,000	4 051
1981	642,000	4 606
1982	251,000	2 790
1983	309,000	2 213
1984	310,000	2 106
1985	308,000	2 014

Sources: Statistics Canada; Energy, Mines and Resources Canada.

.. Not available.

TABLE 3. CANADA, FELDSPAR CONSUMPTION, 1982-85

	1982	1983	1984	1985P
	(tonnes)			
Consumption				
Whiteware	2 655	2 065	1 924	1 924
Other products[1]	135	148	182	90
Total	2 790	2 213	2 106	2 014

[1] Includes porcelain enamel, artificial abrasives and other minor uses.

P Preliminary.

TABLE 5. WORLD MINE PRODUCTION OF FELDSPAR, 1984 AND 1985

	1984	1985e
	(tonnes)	
United States	644	635
Brazil	150	150
France	175	172
Germany, Federal Republic of	335	335
Italy	870	871
Mexico	120	118
Spain	115	118
Other Market Economy Countries	764	762
U.S.S.R.	326	326
Other Centrally Planned Economies	140	140
Total	3 639	3 627

Source: United States Bureau of Mines Mineral Commodity Summaries, 1986.

e Estimated.

Nickel

R.G. TELEWIAK

Nickel consumption is estimated to have increased by 1 per cent to 565 000 t in 1986, led by relatively strong demand in western Europe, particularly in the stainless steel sector. Consumption fell in the United States and Japan. Lower scrap sales also impacted positively upon the demand for primary nickel.

Supplies also increased marginally. While output from western world producers was lower in 1986, exports from the Soviet Union increased dramatically. Exports from the Soviet Unions were estimated to have been 55 000 t compared to 25 000 t the previous year.

Nickel prices started the year relatively strongly but then weakened during the second half. Prices averaged $US 1.83 on the London Metal Exchange (LME) during the first half and $US 1.69 during the second half.

CANADIAN DEVELOPMENTS

Cost reduction programs continued to be a priority of producers, and encouraging results were achieved. Nevertheless, the steep slide in prices resulted in poor financial performance of the companies. Net 1986 earnings for Inco Limited were $US 0.2 million compared to $52.2 million for the same period a year earlier. Falconbridge Limited lost $15.5 million versus earnings of $38.5 million a year earlier.

Inco's operating costs at its Sudbury and Thompson operations were lower in 1986 than in 1980. These cost reductions have been achieved in all parts of the operation, but particularly in mining. One of the key factors in mining has been the gradual switch to bulk mining methods. In 1986, 83 per cent of Sudbury production came from bulk mining methods, compared to 32 per cent in 1982.

In Manitoba, Inco officially opened its Thompson open pit on September 23. This high-grade mine, which cost $100 million to develop, averages 2.7 per cent nickel and has simpler metallurgy and better recoveries than the Pipe mine which it replaces. Consequently, it is one of the world's lowest cost mines.

Inco announced that it will spend $25 million over the next two years to electrify its Crean Hill mine at Sudbury to improve productivity, safety, costs and the workplace environment. This will be the company's first electric mine. Crean Hill was closed in 1978 but production should resume by 1989 with 125 workers, compared to 400 when it closed.

Inco is also consolidating its milling operations at Sudbury. This includes modernization and expansion of the Clarabelle mill and the probable closure of the Frood-Stobie mill. Larger flotation cells will improve efficiency and expand capacity. Both mills currently operate 5 days a week but the refurbished Clarabelle mill could operate 7 days a week.

Falconbridge continued its three-year, $216 million program of preproduction, development and capital expenditures which was started at Sudbury in 1985. Major parts of the program include deepening the Strathcona No. 1 shaft and development of the Craig and Onaping deposits. Falconbridge had fallen behind in mine development a few years ago, due to other priorities.

Inco and Falconbridge continued their efforts to develop solutions to conform to the 1994 sulphur dioxide emission limits set in December 1985 by the Ontario government. Inco is required to reduce emissions to 265 000 tpy of sulphur dioxide, compared to 728 000 tpy in 1985. For Falconbridge, the limit in 1994 will be 100 000 tpy compared

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with 154 000 tpy in 1985. Enhanced pyrrhotite rejection is considered to offer the potential to provide a partial solution to Inco's requirements, and perhaps to be the solution for Falconbridge. Both companies are expected to conduct further research and development before deciding which options will be technically viable and most cost-effective.

Hudson Bay Mining and Smelting Co., Limited and Outokumpu Oy entered into a joint venture arrangement to further explore and possibly develop the high-grade Namew Lake nickel sulphide deposit near Flin Flon, Manitoba. A shaft is being sunk to 1,100 feet from which more detailed exploration of the deposit will be undertaken before a development decision is made. Reserves are currently estimated at 2.6 million t grading 2.4 per cent nickel and 0.9 per cent copper with minor values in platinum and palladium. Development costs of the mine and mill could be $80 million. Life of the operation would be about six years.

Sherritt Gordon Mines Limited produced about 24 000 t of nickel in briquettes and powder at its Fort Saskatchewan, Alberta refinery. The major source of feed continued to be Inco, with concentrates obtained from Thompson and Sudbury. Other sources of feed included nickel matte from Agnew Mining Co. Pty. Ltd. in Australia. In 1987 Sherritt is expected to produce a little less than 23 000 t.

Inco announced late in the year that it would again be taking summer shutdowns in 1987. The Sudbury and Port Colborne operations are scheduled to close from June 29 to August 2 and Manitoba is scheduled to close from July 13 to August 9.

Falconbridge also announced that it would close its Sudbury operations from December 24, 1986 to January 4, 1987 and in July and August 1987. As well, Falconbridge's Kristiansand refinery in Norway will be closed for at least one month during the summer.

The Royal Canadian Mint announced that an 11 sided aureate bronze-coated nickel coin was selected as the new one dollar coin, expected to be in circulation by mid-1987. The coin will be 92 per cent nickel by weight. The Mint anticipates that at least 300 million coins will be required to ensure that the coin is available for general circulation. This will represent an initial market for at least 1 930 t of nickel. It is expected that an additional annual quantity of 160 to 320 t of nickel will be required after the coin is in general circulation.

Canadian nickel consumption is expected to have decreased marginally in 1986 from 1985. Consumption was lower at both the Atlas Steels division of Rio Algom Limited and in the coinage sector.

WORLD DEVELOPMENTS

Nickel consumption was relatively strong in western Europe, particularly in the Federal Republic of Germany. The major German stainless steel producers were reported to be operating close to capacity. Demand from the stainless steel sector was also strong in the United Kingdom, Italy and Sweden.

The strength of demand in Europe, and also the Far East, was partially offset by a decline in useage in the United States and Japan. Overall, western world consumption is estimated to have increased by 1 per cent to 565 000 t.

Nickel prices were weak with the result that some western world producers closed and some others decreased production from planned levels. As well, production was reduced as a result of strikes at some facilities. Some producers including Inco and Cerro Matoso S.A. increased their output but, overall, production was marginally lower.

Net exports from Comecon countries to the western world increased to roughly 55 000 t, compared to 30 000 t in 1985. Soviet Union exports increased to an estimated 55 000 t, from 25 000 t in 1985. Cuban exports were estimated at 8 000 t which were somewhat lower than 1985 exports. China became an exporter in 1986 and shipped about 3 000 t of nickel cathodes, primarily to Japan. China and Toyota entered into a barter arrangement in which nickel was exchanged for automotive parts. Comecon countries imported about 10 000 t from the western world.

In Australia, Agnew Mining Co. Pty. Ltd. mothballed its operation on August 15, citing low nickel prices. Agnew had consistently reported financial losses on the operation since its opening in 1979. Underground problems plagued the operation. It had been considered that a new open-pit mine would be developed while further underground development was undertaken but, given market conditions, this option was cancelled. Agnew matte was being refined by Outokumpu Oy in Finland and Sherritt Gordon in Canada. With supplies in the pipeline, this material continued to be available through the end of the year.

Also in Australia, production by Western Mining Corporation Limited was reduced due to a labour-management dispute. The Queensland government is reported to have offered Queensland Nickel Pty Ltd. $30 million as part of a $42 million package to build a pier and conveyor system at the company's Greenvale processing plant at Yabulu, enabling laterite ore to be imported from either New Caledonia or Indonesia.

In the United States, M.A. Hanna Company indefinitely closed its mine and smelter on August 20. The company had closed the smelter from June 1985 to June 1986 while a wet screening process and slurry transport system were installed. It was expected that costs would be reduced by 20 per cent due to the modifications, which involved upgrading the ore before smelting. However, prices fell by about 25 per cent during the modification period.

Nonoc Mining & Industrial Corporation in the Philippines operated intermittently throughout the year. Initially, production was reduced due to a labour dispute and then was halted at year end due to weak market conditions. An early resumption of production is not expected.

Production at Société minière et métallurgique de Larymna S.A. (LARCO) was lower than planned as a result of labour disputes. The company experienced intermittent work stoppages and its production was less than half of its 27 000 tpy capacity of nickel in ferronickel. LARCO was reported to be considering a plan to rationalise its production to one half of its capacity and to use the excess capacity to make ferro-chrome which would be based upon locally supplied chrome ore. As part of the rationalization, its high cost underground mine would be closed.

Nippon Mining Company Limited of Japan announced that it was suspending nickel and cobalt production at its Hitachi refinery due to the cessation of nickel/cobalt sulphide supplies from Greenvale in Australia. Sumitomo Metal Mining Co. Ltd. cut its nickel output due to difficulty in obtaining feed from Nonoc in the Philippines.

In Colombia, Cerro Matoso S.A. operated at about 80 per cent of its annual capacity of 22 700 t of nickel in ferronickel. In 1985, the company had operated at less than 50 per cent of capacity due to technical difficulties with the furnace. The acidic nature of the ore caused problems with the furnace lining at the matte-slag interface. An Outokumpu cooling system was installed and along with some changes in material handling and operating techniques, the furnace could be operated closer to its design capacity.

Cuba produced about 1 500 t of nickel at its new Punta Gorda plant. One furnace line was operated. Capacity of the plant will be 30 000 t of nickel contained in nickel oxide when all three furnace lines are brought into operation. Originally, production was scheduled to be about 6-7 000 t for 1986 but this was reduced, probably due to a combination of technical difficulties and weak market conditions. Total Cuban nickel production is estimated at 36 000 t in 1986, the same as in 1985.

In Yugoslavia, Feronikl Kosovo continued to produce far below its capacity of 18 000 tpy of nickel in ferronickel. Incontra, which had been the company's sales agent, was reported to have ceased handling material from Kosovo.

Albania's latest five year plan included a 30 to 40 per cent increase in the production of ferronickel and the completion of a nickel-cobalt plant. Salzgitter Industrieban of the Federal Republic of Germany was reported to be constructing a 6 000 tpy electrolytic nickel plant in Elbasan, Albania, to process ferronickel feed.

In South Africa, Western Platinum Limited officially opened its new base-metal refinery near Brits in the western Transvaal. The refinery has the capacity to treat Western Platinum's total production of 4 000 tpy of matte containing about 1 900 t of nickel and 1 000 t of copper. The resulting residue containing platinum group metals and gold is refined at the company's Brakpan refinery near Johannesburg. Falconbridge had processed the matte in Norway prior to construction of the Brits facility.

Late in the year, the United States and the Soviet Union reached a tentative agreement that would permit a resumption of Soviet nickel imports. In 1983, the United States had banned the importation, directly or indirectly, of Soviet nickel after it had been determined that the Soviet nickel product contained Cuban nickel. The Soviet Union imports about half of Cuba's nickel oxide production for refining at Monchegorsk on the Kola Peninsula. While no solution had been formalized, it was believed that the Soviets will certify that nickel produced at certain refineries, including Norilsk, do not contain Cuban nickel.

INTERNATIONAL NICKEL STUDY GROUP

At the United Nations Conference on Nickel, October 28 to November 7, 1985 and April 28 to May 2, 1986, negotiations took place involving over thirty nickel producing and consuming countries, on the Terms of Reference and Rules of Procedure for the International Nickel Study Group (INSG). The United Nations Conference on Trade and Development (UNCTAD) provided the facilities and services for the meetings, which were chaired by Canada.

The functions of the INSG, as stated in the Terms of Reference which were adopted by the Conference, are:

(a) to establish the capacity for and to undertake the continued monitoring of the world nickel economy and its trends, particularly by establishing, maintaining and continuously updating a statistical system on world production, stocks, trade and consumption of all forms of nickel;

(b) to conduct between Members consultations and exchanges of information on developments related to the production, stocks, trade and consumption of all forms of nickel;

(c) to undertake studies as appropriate on a broad range of important issues concerning nickel, in accordance with the decisions of the Group; and

(d) to consider special problems or difficulties which exist or may be expected to arise in the international nickel company.

The Secretary General of the United Nations, at the request of the Conference, forwarded copies of the Terms of Reference to all governments invited to the Conference, and urged governments to notify the Secretary-General of the United Nations of their acceptance of them before September 20, 1986.

The September deadline proved too restrictive to permit many countries to complete their internal approval and budgetary procedures and only five countries (Federal Republic of Germany, Finland, Netherlands, Sweden and Canada) were able to meet it.

An informal meeting of countries interested in establishing an international study group on nickel was held in Geneva on October 16, 1986, to review the status of membership notifications, to assess progress of countries' internal procedures towards accepting membership, and to discuss outstanding issues. Twenty-three countries attended as well as observers from the European Community, the Organization of Economic Cooperation and Development (OECD) and UNCTAD.

At this meeting it became evident that most countries wanted the inaugural meeting to be held in 1987.

PRICES

Nickel prices weakened in the second half of the year. Average quarterly nickel prices on the London Metal Exchange (LME) were $US 1.83, 1.83, 1.73 and 1.64, respectively. The average price for the year was $1.76 compared to $2.22 in 1985.

The increase in Soviet exports along with the uncertainty of the level of these exports, particularly during the first half of the year, were important factors in depressing the price. Increased production by some other producers also contributed to the price decline.

Scrap sales declined as the price for primary nickel fell. The price differential between primary nickel and scrap also narrowed. Scrap dealers were unwilling, despite adequate supplies, to lower their prices in direct proportion to primary nickel prices in order to maintain their markets.

Late in the year Inco instituted a producer price for utility nickel sold in Europe. The European stainless steel producers, the major users of this form of nickel, had been requesting this type of pricing arrangement. Prices will begin to be realized on this basis in early-1987.

USES

Resistance to corrosion, high strength over a wide temperature range, pleasing appearance and suitability as an alloying agent are characteristics of nickel which make it useful in a wide range of applications. The major use is in stainless steels, which account for close to 50 per cent of consumption, followed by nickel-base alloys, electroplating, alloy steels, foundry products and copper-based alloys. Nickel is extensively used as an alloying agent and is a component in some 3,000 different alloys which are used in more than 250,000 end-use applications.

Close to two-thirds of nickel consumption is in capital goods with the remainder in consumer products. Nickel is used in chemical and food processing, nuclear power plants, aerospace equipment, motor vehicles, oil and gas pipelines, electrical equipment, machinery, batteries, catalysts, and in many other applications.

Relatively new end-use markets that will contribute to nickel's consumption growth in the future are pollution abatement equipment, cryogenic containers, barnacle-resisting copper-nickel alloy plating for boat hulls, and nickel-cadmium batteries for standby power applications.

Some new alloys have been recently developed which could have an attractive future. One of these, a zinc-nickel alloy, is being used by Mazda in Japan for use in a galvanizing process for automobile applications and is being examined by other automotive manufacturers. The product is more corrosion resistant than regular galvanized steel. The enhanced appearance and low weight make this type of product potentially attractive for certain other uses, such as galvanized steel lamp posts.

Another nickel-based alloy, altraloy, has been developed which may displace gold in some electronic applications. Nickel is combined with iridium to make a low-cost connector or surface contact material.

OUTLOOK

Overcapacity has had an important influence on the market for several years and it is expected that this will continue through the remainder of this decade. Some new capacity is being developed, including expansions in Cuba, and this in combination with expected slow growth in consumption, will result in continued overcapacity.

Neverthless, there are some encouraging developments which should affect the market over the medium-term to longer term. Nickel producers have reduced their production costs in recent years, primarily due to reduced employment and the introduction of improved techniques and equipment, and it is expected that many of these cost-cutting measures will be permanent. As a result, nickel prices will not need to be as high as previously thought for producers to be profitable. Prices are likely to be considerably lower than many analysts were forecasting a few years ago and this will encourage increased consumption and reduce the threat of substitution by other metals, plastics, ceramics and other materials.

The Nickel Development Institute, which was established in 1984, is also likely to have a positive impact on demand over the longer term. The Institute, headquartered in Toronto and supported by most major western world producers, is encouraging the use of nickel through market promotion programs and research into new uses for nickel. By the end of 1986, the Institute had initiated more than 50 market development, market exploration and end-use research projects in various parts of the world. Small liaison offices to serve different market areas had been set up in the United Kingdom, Japan, India and Brazil.

Given the expected, relatively modest nickel prices and the high costs of establishing new capacity, return on investment is not likely to be sufficient to encourage installation of much new capacity. This should bring capacity and supply into better balance in the 1990s.

Consumption is expected to grow at an annual rate of about 1.7 per cent to the year 2000. While some more mature markets, like the United States and Japan, are expected to experience somewhat lower growth rates, this will be offset by higher rates in relatively small but emerging markets such as China, Brazil and South Korea.

With the closer balance between capacity and demand in the 1990s, some real increase in prices can be expected. Producer realized prices in constant 1986 dollars (U.S.) could increase to about $2.15 per pound in the 1990s.

Nickel production in Canada is expected to increase slowly to the year 2000 (Table 6) but will unlikely reach the 1970 peak production of 277 000 t. Canada is expected to remain a highly cost-competitive producer, particularly given the cost reduction programs which are under way. An increasing amount of ore will be mined by low-cost bulk mining methods and this will be a significant factor in lowering costs, given that mining accounts for about 50 per cent of current operating costs. The Thompson open pit will also supply low cost ore. A constraint on production, particularly at Inco, Sudbury, will be the limit on permissible sulphur dioxide emissions from the smelter.

In the short-term, we believe that consumption of primary nickel will change little in 1987, compared to 1986. Supplies are expected to continue to be higher than demand, particularly if Soviet exports remain at or near 1986 levels as many analysts are predicting. Scrap supplies are also expected to be higher. Oversupply will be a critical factor in keeping prices under pressure. Nickel prices on the LME could average a few cents lower than the $US 1.76 realized in 1986, unless supplies are reduced from expected levels.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
CANADA					
32900-1	Nickel ores, n.o.p.	free	free	free	free
	Natural oxides, n.o.p., not including ores of metals:				
33506-1	Nickelous oxide	10.0	12.8	25.0	8.5
35500-1	Nickel and alloys containing 60% by weight or more, n.o.p., viz.: ingots, blocks and shot; shapes or sections, billets, bars and rods, rolled, extruded or drawn (not including nickel processed for use as anodes); strip; sheet and plate (polished or not); seamless tube:	free	free	free	free
35505-1	Rods containing 90% or more of nickel, when imported by manufacturers of nickel electrode wire for spark plugs, for use exclusively in manufacture of such wire for spark plugs in their own factories:	free	free	10.0	free
35510-1	Metal alloy strip or tubing - not being steel strip or tubing - containing not less than 30% by weight of nickel and 12% by weight of chromium, for use in Canadian manufactures:	free	free	20.0	free
35515-1	Nickel and alloys containing 60% by weight or more of nickel, in powder form:	free	free	free	free
35520-1	Nickel or nickel alloys, namely: matte, sludges, spent catalysts and scrap, and concentrates other than ores	free	free	free	free
35800-1	Anodes of nickel	free	free	10.0	free
	Ferroalloys:				
37506-1	All alloys used in the manufacture of steel or iron, n.o.p.	free	4.2	5.0	free
44643-1	Articles of nickel, or of which nickel is the component material of chief value for use in the manufacture of electric storage batteries	7.2	7.2	20.0	4.5

MFN Reductions under GATT (effective January 1 of year given)	1986	1987
33506-1	12.8	12.5
37506-1	4.2	4.0
44643-1	7.2	6.8

TARIFFS (cont'd)

Item No.		British Preferential	Most Favoured Nation		General	General Preferential
			(%)			
UNITED STATES (MFN)						
	Nickel compounds:					
419.72	Oxide		free			
	Mixtures of two or more inorganic compounds:					
423.90	In chief value of nickel oxide		free			
	Metal-bearing ores and the dross or residuum from burnt pyrites:					
601.36	Nickel ore		free			
606.20	Ferronickel:		free			
	Unwrought nickel; nickel waste and scrap:					
620.03	Unwrought nickel		free			
620.04	Nickel waste and scrap		free			
620.32	Nickel powders		free			
620.47	Pipe and tube fittings if Canadian article and original motor vehicle equipment:		free			
			1986	1987		
	Nickel compounds:					
419.70	Chloride		3.9	3.7		
419.74	Sulfate		3.4	3.2		
419.76	Other		3.9	3.7		
	Nickel salts:					
426.58	Acetate		3.9	3.7		
426.62	Formate		3.9	3.7		
426.64	Other		3.9	3.7		
	Bars, plates, sheets, and strip, all the foregoing wrought, of nickel, whether or not cut, pressed, or stamped to nonrectangular shapes/other:					
620.08	Plates and sheets, clad		6.8	6.0		
620.10	Other, not cold worked		3.7	3.5		
620.12	Other, cold worked		5.0	4.7		
620.16	Cut, pressed or stamped to nonrectangular shapes		5.9	5.5		
	Rods and wires:					
620.20	Not cold worked		3.9	3.7		
620.22	Cold worked		5.0	4.7		
620.26	Angles, shapes and sections		5.9	5.5		
620.30	Nickel flakes, per pound:		0.6¢	free		
	Pipes, tubes and blanks, therefor, pipe and tube fittings all the foregoing of nickel					
620.40	Not cold worked		2.6	2.5		
620.42	Cold worked		3.1	3.0		
620.46	Pipe and tube fittings		4.3	3.6		
620.50	Electroplating anodes, wrought		3.9	3.7		
	or cast, of nickel		3.9	3.7		
642.06	Nickel wire strand		5.0	4.7		
657.50	Articles of nickel, not coated					
	or plated with precious metal:		5.9	5.5		

Sources: The Customs Tariff, January 1986, Revenue Canada Customs and Excise; Tariff Schedules of the United States Annotated (1986), USITC Publication 1775.
n.o.p. Not otherwise provided for.

TABLE 1. CANADA, NICKEL PRODUCTION, TRADE AND CONSUMPTION, 1984-86

	1984^{r}		1985		1986^{p}	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Production[1]						
All forms						
Ontario	133 048	890,975	131 035	930,760	137 004	815,858
Manitoba	40 677	275,165	38 936	286,628	43 595	259,609
Total	173 725	1,166,140	169 971	1,217,388	180 599	1,075,467
Exports					(Jan. - Sept.)	
Nickel in ores, concentrates and matte[2]						
Norway	31 049	193,329	29 981	196,935	21 493	119,545
United Kingdom	27 420	191,049	29 895	212,199	19 810	140,750
Japan	821	3,981	-	-	-	-
United States	119	341	61	427	-	-
Other	-	-	12	96	-	-
Total	59 409	388,700	59 949	409,657	41 303	260,295
Nickel in oxides						
United States	8 874	76,556	9 284	54,749	..	12,602
EEC	2 455	20,042	1 390	12,244	..	6,252
Other countries	8 750	47,419	7 318	58,417	..	60,549
Total	20 079	144,017	17 992	125,410	..	79,403
Nickel and nickel alloy scrap						
United States	3 900	17,779	2 577	12,428	2 878	12,737
Netherlands	3 436	18,235	1 286	7,916	747	3,170
Austria	-	-	13	2	-	-
South Korea	222	1,360	265	1,800	144	813
Other countries	2 037	10,737	685	3,616	558	811
Total	9 595	48,111	4 826	25,762	4 327	17,532
Nickel anodes, cathodes, ingots, rods						
United States	45 729	275,659	46 923	279,473	..	213,251
EEC	14 193	80,742	20 739	128,918	..	83,223
Other countries	94 013	561,950	13 939	87,452	..	50,282
Total	153 935	918,351	81 601	495,843	..	346,756
Nickel and nickel alloy fabricated material, nes						
United States	8 887	69,870	8 663	69,186	5 450	43,016
South Africa	116	956	866	7,567	1	37
Belgium-Luxembourg	509	3,658	573	3,164	476	2,707
Hong Kong	34	266	104	627	68	434
United Kingdom	335	2,367	417	2,509	330	1,727
Japan	312	2,117	1 124	9,697	816	5,440
Other countries	610	4,544	595	5,251	684	5,084
Total	10 803	83,778	12 342	98,001	7 825	58,445

Imports						
Nickel in ores, concentrates and scrap						
Australia	4 017	17,421	6 250	32,332	7 505	33,340
United States	9 978	14,989	15 450	24,024	11 151	13,620
United Kingdom	6 303	11,014	6 567	7,733	7 409	10,367
Belgium-Luxembourg	2 486	2,365	2 112	1,710	557	592
Norway	1 488	1,112	97	461	2 348	2,136
Other countries	463	733	1 082	2,428	347	789
Total	24 735	47,634	31 558	68,688	29 317	60,844
Nickel anodes, cathodes, ingots, rods						
Norway	2 423	18,583	1 788	13,143	904	6,413
United States	972	6,494	917	6,974	838	5,484
United Kingdom	39	266	17	173	20	149
Netherlands	-	-	-	-	-	-
Other countries	46	317	42	313	56	486
Total	3 480	25,660	2 764	20,603	1 818	12,532
Nickel alloy ingots, blocks, rods and wire bars						
United States	588	6,848	389	4,621	276	3,613
West Germany	33	239	184	1,363	45	378
Other	-	-	1	11	-	-
Total	621	7,087	574	5,995	321	3,991
Nickel and alloy plates, sheet, strip						
United States	529	7,156	606	9,808	453	6,606
West Germany	470	3,171	658	4,159	550	3,774
Sweden	4	30	17	93	1	9
Other countries	7	57	29	258	23	229
Total	1 010	10,414	1 310	14,318	1 027	10,618
Nickel and nickel alloy pipe and tubing						
Sweden	365	3,453	233	2,331	69	1,289
United States	129	2,172	128	2,187	86	1,832
West Germany	63	953	67	783	41	489
Other countries	70	1,138	101	1,543	236	2,973
Total	627	7,715	529	6,844	432	6,583
Nickel and alloy fabricated material, nes						
United States	460	11,722	627	19,277	384	15,384
United Kingdom	36	580	17	239	64	448
West Germany	52	517	143	1,904	73	763
Japan	2	8	4	17	1	8
Other countries	9	103	25	359	5	63
Total	559	12,930	816	21,796	527	16,666
Consumption[3]	7 290	..	5 950	..	..	..

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Refined nickel and nickel in oxides and salts produced, plus recoverable nickel in matte and concentrates exported. [2] For refining and re-export. [3] Consumption of nickel, all forms (refined metal and in oxides and salts) as reported by consumers.

p Preliminary; r Revised; - Nil; .. Not available; nes Not elsewhere specified.

TABLE 2. CANADA, NICKEL PRODUCTION, TRADE AND CONSUMPTION, 1970, 1975 AND 1980-86

		Exports					
	Production[1]	In Matte etc.	In Oxide Sinter	Refined Metal	Total	Imports[2]	Consumption[3]
				(tonnes)			
1970	277 490	88 805	39 821	138 983	267 609	10 728	10 699
1975	242 180	84 391	38 527	91 164	214 082	12 847	11 308
1980	184 802	42 647	16 989	88 125	147 761	4 344	9 676
1981	160 247	53 841	14 390	79 935	148 166	2 335	8 603
1982	88 581	27 037	13 127	62 314	102 478	2 588	6 723
1983	125 022	40 087	11 167	66 949	118 203	2 357	5 010
1984[r]	173 725	59 409	20 079	153 935	233 423	3 480	7 290
1985	169 971	59 949	17 992	81 601	159 542	2 764	5 950
1986P	180 599	..	..	..	..	..	..

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Refined metal and nickel in oxide and salts produced, plus recoverable nickel in matte and concentrates exported. [2] Refined nickel, comprising anodes, cathodes, ingots, rods and shot. [3] Consumption of nickel, all forms (refined metal, and in oxides and salts) as reported by consumers.
P Preliminary; [r] Revised; .. Not available.

TABLE 3. CANADIAN PROCESSING CAPACITY, 1985

	Inco			Falconbridge	Sherritt Gordon
	Port Colborne	Sudbury	Thompson	Sudbury	Fort Saskatchewan
		(tpy of contained nickel)			
Smelter	n.a.	127 000[1]	81 600	45 000	n.a.
Refinery	65 000[2]	56 700	55 000	n.a.	24 000

[1] Reduced from 154 200 t due to a government regulation on SO_2 emissions imposed in 1980.
[2] Electrolytic nickel portion of refinery closed in 1984, only utility nickel currently being produced.
n.a. Not applicable.

TABLE 4. WORLD MINE PRODUCTION OF NICKEL, 1984 AND 1985

	1984	1985
	(tonnes)	
U.S.S.R.	175 000	175 000
Canada[1]	173 700	170 000
Australia	76 900	85 500
New Caledonia	58 300	61 200
Indonesia	47 800	48 200
Cuba	36 000	36 000
South Africa	22 500	29 000
Botswana	18 600	19 600
People's Republic of China	17 500	19 000
Dominican Republic	16 500	14 000
Other	99 200	177 000
Total	742 000	774 500

Sources: World Bureau of Metal Statistics; Energy, Mines and Resources Canada.

[1] Refined nickel and nickel in oxide and salts produced, plus recoverable nickel in matte and concentrates produced.

TABLE 5. WORLD CONSUMPTION OF NICKEL, 1984 AND 1985

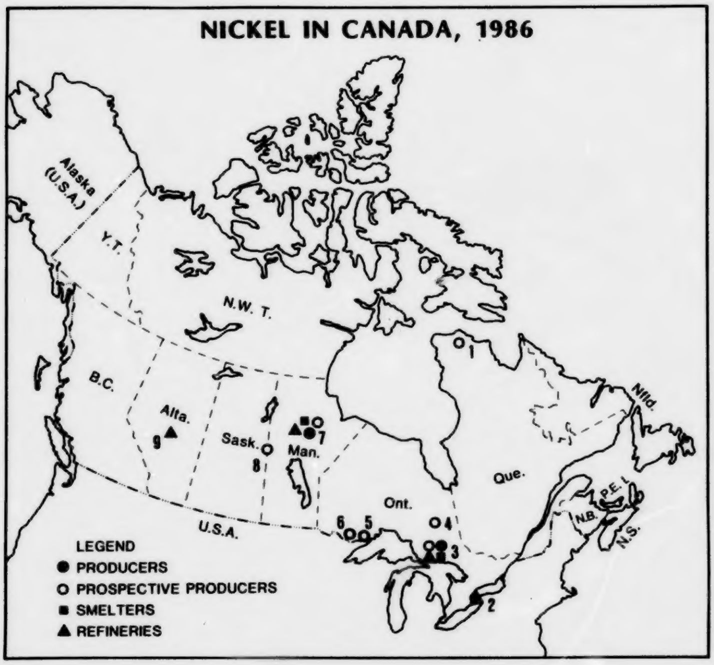
	1984	1985
	(tonnes)	
U.S.S.R.	150 000	156 000
United States	141 000	146 900
Japan	146 000	136 100
Germany, F.R.	78 000	76 300
France	38 900	32 300
Italy	28 000	29 000
United Kingdom	26 100	24 800
People's Republic of China	20 000	21 000
Sweden	20 400	17 000
India	15 200	14 000
Other	124 800	133 400
Total	788 400	786 800

Sources: World Bureau of Metal Statistics; Energy, Mines and Resources Canada.

TABLE 6. FORECAST OF CANADIAN MINE PRODUCTION[1]

Year	Inco Sudbury	Inco Thompson	Falconbridge Sudbury	Total
		(tonnes)		
1987	105 000	45 000	27 200	177 200
1988	108 000	49 000	30 000	187 000
1989	109 000	50 000	33 000	192 000
1990	110 000	50 000	35 500	195 500
2000	116 000	50 000	37 000	203 000

[1] From existing mining areas; does not include likely production from greenfield developments, such as Namew Lake.


NICKEL IN CANADA, 1986

Alaska (U.S.A.)
Y.T.
N.W. T.
B.C.
Alta.
Sask.
Man.
Ont.
Que.
Nfld.
P.E.I.
N.B.
N.S.
U.S.A.
1
2
3
4
5
6
7
8
9
LEGEND
● PRODUCERS
○ PROSPECTIVE PRODUCERS
■ SMELTERS
▲ REFINERIES

Producers, prospective producers, smelters and refineries
(numbers refer to locations on map above)

Producers

3. Falconbridge Limited
   (East, Fraser, Lockerby, North, Strathcona)
   Inco Limited
   (Clarabelle, Copper Cliff North, Copper Cliff South, Creighton, Frood, Garson, Levack, Little Stobie, McCreedy West and Stobie)
7. Inco Limited (Thompson and Thompson open pit)

Prospective Producers

1. New Quebec Raglan Mines Limited
3. Falconbridge Limited
   (Craig, Lindsley, Onaping, Onex, Thayer mines)
   Inco Limited (Coleman, Crean Hill, Murray, Totten)
4. Teck Corporation (Moncalm Township)
5. Great Lakes Nickel Limited (Pardee Township)
6. Inco Limited (Shebandowan mine)
7. Inco Limited
   (Soab North, Soab South, Birchtree, Pipe No. 1)
8. Hudson Bay Mining and Smelting Co., Limited (Namew Lake)

Smelters

3. Falconbridge Limited (Falconbridge)
   Inco Limited (Sudbury)
7. Inco Limited (Thompson)

Refineries

2. Inco Limited (Port Colborne)
3. Inco Limited (Sudbury)
7. Inco Limited (Thompson)
9. Sherritt Gordon Mines Limited (Fort Saskatchewan)

Peat

M. PRUD'HOMME

Peat is an intermediate compound resulting from the biochemical decomposition of plant matter. In its raw material form, it is ligneous, fibrous and elastic. It has a pH of 2.8 to 4.0 and an ash content of 0.5 to 2.5 per cent. Peat is composed of organic residues accumulated from the anaerobic decomposition of plant matters. Peat is found in peat bogs, swamps and marshes. Its main properties are its high water-retaining capacity, low density, high resistance to decomposition, low heat conductivity and high porosity. It can hold up to twenty times its weight in liquids and gas. Peat is divided into two principal types according to its botanical composition and degree of decomposition. Horticultural peat is relatively undecomposed, with a von Post value of H1 to H5. It has a high fibre content, is light yellowish brown in colour and contains few colloids. Fuel peat is highly decomposed, with a von Post value of H6 to H10. It is blackish in colour and contains colloid residues.

The total area of peatlands in Canada is estimated at 111 328 000 hectares (ha), covering close to 12 per cent of the country's land surface. Approximately 60 per cent of all Canadian peatlands are perennially frozen. Indicated peat resources total approximately 3 004 996 million m^3, equivalent to 338 000 million t of dry peat. Measured resources are estimated at 1 092 million t. In Canada, close to 280 000 ha of peatland are currently used for agricultural purposes.

Peat production in Canada is limited to a short harvesting season - from June to September due to weather conditions which hinder drainage and drying of the peat.

Canada mainly produces sphagnum peat, which is used in horticulture and agriculture. It is harvested primarily in eastern and southeastern Quebec, and in northeastern and eastern New Brunswick. A small amount of hypnum moss is also produced in Alberta and Ontario. Peat moss is the terminology for commercial use of peat in horticulture.

USES

Sphagnum peat is extracted from peatlands and dried. After the fibres are removed, it is pressed into bales. It is marketed in three forms. In its natural state, peat is sold in bulk form within a 100 km radius of production centres. When packaged in bags or bales, peat is compressed using a ratio of 2:1. The most common bale sizes are 170 dm^3 (6 ft^3), 113 dm^3 (4 ft^3), and 56 dm^3 (2 ft^3). Peat is mixed with fertilizers and other products, such as vermiculite and perlite, to form a substrate, and with limestone, soil and fertilizers to form potting soil.

Because of the range of its physical and chemical properties, peat has many uses. It is used in its natural state in agriculture and horticulture to loosen up clay soils, to maintain moisture in sandy soils and to add organic matter and fertilizers to depleted soils. Peat is also used as a horse, cattle and poultry litter to absorb liquids and odours. Peat is used in the production of artificial mixtures such as potting soil, seed carriers, peat-perlite and peat-vermiculite mixes, fertilizers and composts. It is used in the production of peat pots for sprouting plants.

Peat has several industrial applications. It can be used in the production of paper towels, chemical products, metallurgical coke and activated carbon (charcoal). Peat is also used to purify industrial and residential effluents. Its cellular structure, absorbing properties and high capacity for ionic exchange constitute adequate qualities for it to be used as a natural filter. Peat can reduce the acidity of drainage from old mines and remove iron oxydes from waste and drainage water. Peat acts as an aid for therapy in balneology, gynaecology and rheumatology. Peat moss has been used as an oil spillage absorbent and in medical tampons.

Fuel peat is recognized as an alternate source of energy. This form of biomass is widely used as fuel in several European

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countries, such as Ireland and Finland, and in the U.S.S.R. The calorific value of dry Canadian peat is approximately 4 700 to 5 100 kcal/kg, compared with oil at 9 900 to 10 000 kcal/kg and coal at 4 800 to 5 800 kcal/kg. Peat, as a fuel, is fired in furnaces to produce the steam needed to drive turbines generating electricity. Fuel peat can be processed to produce coke, synthetic natural gas and methanol. Fuel peat has a high degree of humification, a high bulk density, a high calorific value, a low ash content, and a low percentage of pollutants such as sulphur and mercury.

PRODUCTION AND TRADE IN CANADA

In 1986, peat production was estimated at 587 000 t, a significant drop of 8.5 per cent from 1985 due to poor weather conditions. The rates of production were lower, especially in Quebec where there was a decline of 25 per cent. Reduced harvesting resulted in a seasonal shortage and a tight market situation which triggered short term increases in prices for peat bales. Normal market conditions should resume by mid-1987 at the beginning of the harvesting period.

In 1986, the value of production rose by 17 per cent to $74 million as the average unit value rose significantly by 28 per cent due to large increases in value in Manitoba and Quebec. Quebec accounted for 39 per cent of total peat production in terms of tonnage, followed by New Brunswick (32.5 per cent), Manitoba (12.5 per cent) and Alberta (10 per cent). More than 90 per cent of Canadian peat production is for use in horticulture, nurseries, landscaping, and potato and mushroom growing. Apparent consumption of peat in Canada is estimated at 10 per cent of the total volume of shipments, the remainder being exported.

In 1985, Canadian imports of peat moss were valued at $713,000; these originated from the United States (73.5 per cent), Norway (8 per cent), the United Kingdom (7 per cent), France (6.5 per cent), Ireland (2.5 per cent) and Denmark (2.5 per cent), and were shipped to Ontario (81 per cent), British Columbia (11 per cent) and Quebec (6 per cent). Canadian exports amounted to 446 524 t and were valued at $83 million. In the first nine months of 1986, Canada exported approximately 420 000 t, an increase of 17 per cent compared to the same period in 1985. The United States accounted for 93.3 per cent of total peat exports, followed by Japan (6 per cent), Puerto Rico and Saudi Arabia. In 1986, the unit value of exported peat was $199 per t, a 7 per cent increase over 1985.

DEVELOPMENTS IN CANADA

La Corporation de Développement Industriel du Centre de la Mauricie in Quebec received some federal assistance from EMR to conduct a feasibility study for the exploitation of a peat bog near Lac-à-la-Tortue. This peat bog is one of the largest along the St. Lawrence River.

In the Lac Saint-Jean area, a project to manufacture sanitary products from peat has been studied by Johnson and Johnson Co. The products would be processed through a paper machine owned by the Saint-Raymond Paper Co. in Desbiens.

In Quebec, progress was made with the installation of new laboratories at the Bureau de Recherche sur l'Industrie de la Tourbe dans l'Est du Quebec (BRITEQ). BRITEQ is a non-profit corporation, incorporated in 1978, which has set up a specialized documentation centre and training course on the maintenance of machinery for peat operations. The Bureau is located in Rivière-du-Loup and expects to become a scientific partner to the Quebec peat industry through applied research programs and services as a physical-chemical analysis laboratory.

The Newfoundland Department of Mines and Energy of sponsored a project to demonstrate the feasibility of harvesting sod peat for fuel substitution in the Burin Peninsula.

In New Brunswick, the Centre for Research and Development on Peat was formally reopened in May 1986. Since 1983, the Centre has been contributing to the development of the peat industry in northeastern New Brunswick. Located on the Shippagan University Centre campus, the Centre provides quality control services, research facilities for new industrial products from peat and training for scientists. During 1986, research work has been conducted on the composting of peat with fish and crab wastes and the experimentation of new uses for cutover peat bogs.

In New Brunswick, Jiffy Products (N.B.) Ltd. of Lamèque has developed a new peat product, the Jiffy-7, which is a peat pellet for growing forestry seedlings. The compressed sphagnum peat pellet offers extensive and vigorous root development resulting in improved interface with soil media and integrity of root system. The Jiffy system is designed on quality and consistency of the soil medium, and precision seeding.

During 1986, shipping rates for Canadian peat to Japan were reassessed by Japanese carriers with an increase which could affect trade in a bulky commodity such as peat moss, especially from eastern Canada.

WORLD PRODUCTION AND FOREIGN TRADE

In 1985, world peat production amounted to 256.8 million t of which 72 per cent were for agricultural and horticultural uses. World production has remained steady for the last four years while Canadian production grew significantly by 32 per cent over this period. The U.S.S.R. is the largest producer of agricultural peat, accounting for 93.3 per cent of total world production. Canada ranks fourth, with a 0.25 per cent share.

In the United States, apparent consumption was 1 168 000 t in 1986, a slight 2 per cent increase from the 1985 level, while imports which accounted for 41 per cent of the consumption tonnage remained steady at 435 000 t. In 1986, U.S. production totalled 735 000 t and sales amounted to 807 000 t, valued at about $US 20 million. Eighty-two active producers were operating in 22 states, but mainly in Florida, Michigan, Illinois, Colorado and Indiana. Packaged peat accounted for 55 per cent of total U.S. peat sales. Sphagnum peat moss was mainly used for soil improvement, mixed fertilizers and potting soils, and accounted for only 2 per cent of total production which is dominated by reed-sedge (68 per cent) and humus peat (22 per cent). Canadian peat accounted for 95 per cent of total peat imports, with a value of $US 54 million, and was mainly imported through New York (42 per cent), North Dakota (20 per cent), Montana (11 per cent), Michigan (10 per cent) and Maine (7 per cent).

Japan is the second largest importer of Canadian peat, accounting for 6 per cent of total Canadian peat exports in 1986, compared to 6.8 per cent in 1985. In 1985, Canadian peat exports to Japan rose by 5 per cent to 21 033 t, and for the first nine months of 1986, shipments increased by 42.5 per cent to 24 800 t, valued at $5.5 million. Canada remains the principal peat supplier in Japan with 96 per cent of total peat imports, followed by West Germany (2 per cent) and Finland (1.1 per cent). New Brunswick was the major supplier of Canadian peat to Japan accounting for 70 per cent of total imports. In Japan, peat is used in rice cultivation, horticulture and landscaping. The peat market is tight and prices are competitive but demand for sphagnum peat moss is growing at an annual average rate of 10 per cent, peaking at 28 per cent in 1986.

OUTLOOK

The tight market situation that prevailed late in 1986 and forced prices for Canadian sphagnum peat upward, should settle when the production resumes in 1987. In the short term, distributors and suppliers will ensure shipments only to their principal customers and restrict availability for small new customers.

The North American market for peat is stable and relatively mature with forecast growth estimated at about 3 per cent annually. Canadian producers will continue to focus their promotional efforts on overseas markets. The Japanese market is expanding as demand increased steadily over the last five years. New market opportunities should be exploited in the Middle East where, in some countries, the development of agriculture becomes a top priority. The European market may be accessible if producers can meet customers' specifications through the formation of well-established distribution networks, and under the conditions of favourable exchange rates for Canadian products.

Peat producers will pursue research for new peat products for use in horticulture and industrial applications. Growing medium peat mixes should provide opportunities since demand for mixes is expanding in North America at a faster rate than for peat bales. Sphagnum peat moss from Canada is likely to continue to be preferred over other kinds of peat in the large American market because of its qualities such as water retention and fibrous structure. Chunky peat is being developed as a substitute to the more expensive block cut peat and is likely to be used for horticultural purposes. Demand for peat-vermiculite and perlite mixes should grow in the medium term because of the good conditioning provided to soil from their excellent insulation and root anchorage properties.

Industrial applications will be developed for peat, creating new sales opportunities in the North American market. Activated carbon, absorbent, sanitary products and pelletizing agents could become new peat-based products which could readily be manufactured in Canada.

The U.S. Bureau of Mines has estimated that U.S. demand for peat could reach 1 270 000 t by 1990 and 1 814 000 t by the year 2000, an annual average rate of growth of 3.4 per cent. In the year 2000, world demand for peat, including fuel peat in the U.S.S.R., Finland and Ireland could reach 535 million t.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
CANADA					
54005-1	Grasses, seaweed, mosses and vegetable fibres other than cotton, not coloured, nor further manufactured than dried, cleaned, cut to size, ground and sifted	free	free	free	free
54010-1	Grasses, seaweed, mosses and vegetable fibres other than cotton, nop; whether or not dried, cleaned, cut to size, ground and sifted	free	free	17.5	free
71115-1	Pots or compressed pellets wholly or in chief part of peat, for use in growing plants	7.2	7.2	25	45
93100-1	Fertilizer, formulated; Goods for use as fertilizers	free	free	free	free

MFN Reductions under GATT (effective January 1 of year given)	1986	1987
	(%)	
71115-1	7.2	6.8

UNITED STATES		Most Favoured Nation		Non-MFN
		1986	1987	1986
192.5000	Peat moss Poultry grade	free	free	50¢ per long ton
480.8060	Peat moss Fertilizer grade	free	free	free

Sources: The Customs Tariff 1986, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated (1986), USITC Publication 1775; U.S. Federal Register.
nop Not otherwise provided for.

TABLE 1. PEAT RESOURCES OF CANADA

	Peatland areas		Indicated volume of peat (oven dry)
	ha x 10^3	% of total Canadian Peatlands	tonnes x 10^6
Newfoundland - Labrador	6 429	6	24 945
Prince Edward Island	8	..	30
New Brunswick	120	..	466
Nova Scotia	158	..	613
Quebec	11 713	11	40 057
Ontario	22 555	20	77 138
Manitoba	20 664	19	58 893
Saskatchewan	9 309	8	26 532
Alberta	12 673	11	36 118
British Columbia	1 289	1	4 410
Northwest Territories	25 111	23	65 841
Yukon Territory	1 298	1	2 960
Total	111 328	100	338 003

Source: Peat Resources of Canada, C. Tarnocai, Agriculture Canada, NRCC 24140, 1984.
.. Amount too small to be expressed.

TABLE 2. CANADA, PEAT PRODUCTION[1] BY PROVINCE, 1982-86

Province	1982		1983		1984		1985r		1986p	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
	(000 t)	($ 000)	(000 t)	($ 000)	(000 t)	($ 000)	(000 t)	($ 000)	(000 t)	($ 000)
Newfoundland	0	0	3	20	1	44	1	120	1	240
Prince Edward Island	0	0	0	0	4	1,110	4	685	(2)	(2)
Nova Scotia	10	2,172	10	2,008	5	1,424	9	1,600	6	1,150
New Brunswick	155	11,425	151	9,792	151	10,974	175	14,700	191	18,440
Quebec	203	16,802	238	18,216	234	17,170	294	21,870	231	24,770
Ontario	4	806	4	546	5	733	6	755	6	680
Manitoba	44	7,840	54	7,266	71	9,837	87	10,560	73	13,800
Saskatchewan	4	609	8	1,053	10	1,335	11	1,600	17	2,480
Alberta	47	6,922	47	6,585	49	7,555	56	12,455	58	12,820
British Columbia	20	3,162	14	2,324	11	1,634	4	110	3	110
Total	487	49,738	529	47,810	541	51,816	643	63,770	587	74,500

p Preliminary; r Revised.
[1] Shipments.
(2) Shipments included in Nova Scotia figures to ensure the confidentiality of data.

TABLE 3. CANADIAN, DOMESTIC EXPORTS OF PEAT, BY COUNTRY, 1982-86

Country	1982		1983		1984		1985		1986[P]	
	Tonnage	Value ($ 000)	Tonnage	Value ($ 000)	Tonnage	Value ($ 000)	Tonnage	Value ($ 000)	Tonnage	Value ($ 000)
									(Jan.-Sept.)	
Australia	360	219	231	153	83	54	10	9	61	32
Barbados	11	10	0	0	0	0	20	8	0	0
Bermuda	83	20	186	42	86	40	70	22	40	15
Chile	11	6	5	3	0	0	8	2	0	0
China	22	3	28	6	0	0	0	0	0	0
Costa Rica	11	2	0	0	247	113	85	12	11	3
Cuba	0	0	0	0	0	0	5	3	1	2
Denmark	119	49	0	0	128	137	0	0	0	0
Dominican Republic	0	0	15	5	0	0	0	0	35	15
Egypt	14	6	0	0	0	0	0	0	0	0
Emirates, U.A.	0	0	0	0	30	8	0	0	0	0
France	17	2	0	0	0	0	0	0	0	0
Germany West	2	2	0	0	47	63	11	5	35	14
Greenland	16	3	6	1	0	0	14	8	38	7
Haiti	13	4	12	10	55	26	92	71	143	121
Honduras	0	0	0	0	0	0	30	23	0	0
Hong Kong	92	31	67	21	52	13	20	3	116	18
India	0	0	0	0	0	0	17	1	0	0
Israel	330	119	95	17	0	0	0	0	0	0
Japan	12 256	6,959	17 395	3,676	20 717	4,218	21 033	4,523	31 549	7,240
Korea South	0	0	30	7	30	7	30	7	49	12
Kuwait	0	0	0	0	0	0	265	82	0	0
Leeward-Windward Islands	0	0	0	0	0	0	6	1	12	6
Mexico	68	18	15	3	0	0	0	0	0	0
Netherlands	11	3	12	1	0	0	0	0	17	5
Neth. Antilles	0	0	0	0	19	5	0	0	0	0
Norway	411	53	17	4	0	0	0	0	0	0
Panama	26	9	32	6	22	14	22	8	0	0
Puerto Rico	457	137	729	162	822	223	1 337	264	2 136	553
St. Pierre and Miquelon	0	0	2	1	0	0	0	0	209	38
Saudi Arabia	3 013	1,228	2 937	967	912	269	77	20	576	217
Singapore	17	6	0	0	0	0	15	6	16	7
South Africa	201	34	270	57	397	150	322	81	300	59
Taiwan	25	9	19	8	0	0	24	6	0	0
Trinidad - Tobago	0	0	0	0	89	39	63	51	46	15
United Kingdom	8	1	0	0	19	5	0	0	0	0
United States	338 447	64,547	374 760	65,236	436 845	76,818	422 939	78,446	499 607	101,574
Venezuela	0	0	11	1	0	0	0	0	0	0
Virgin Islands	0	0	9	4	0	0	11	6	0	0
Total	356 030	69,182	396 883	70,391	460 600	82,203	446 524	83,667	534 997	109,952

Source: Statistics Canada.
[P] Preliminary.

TABLE 4. WORLD PRODUCTION OF PEAT, BY COUNTRY, 1981-85

Country	1981[r]	1982[r]	1983[r]	1984P	1985[e]
			(000 tonnes)		
Agricultural use					
U.S.S.R.[re]	180 000	180 000	180 000	180 000	180 000
West Germany	1 741	1 841	1 868	1 428	1 815
United States	622	724	638	715	750
Canada	462	487	529	500	645
Netherlands[e]	400	400	400	450	450
France[e]	131	120	110	225	200
Poland[e1]	202	200	200	200	200
Sweden	131	123	125	125	125
Finland[r]	70	198	94	85	120
Ireland	81	95	95	95	105
Hungary[e]	70	70	70	70	70
Norway[e]	60	60	60	60	60
Spain	39	60	40	55	50
Denmark	31	34	30	30	35
Israel	20	20	20	20	20
Total[2]	183 882	184 476	184 118	184 058	184 645
Fuel use					
U.S.S.R.[e]	59 862	59 862	59 862	59 860	60 000
Ireland	5 357	5 279	6 648	7 932	7 650
Finland	1 302	5 499	3 354	2 712	3 190
West Germany	246	253	258	275	270
Norway[e]	1	1	1	1	1
Other	201	198	1 590	1 448	1 089
Total[2]	66 969	71 092	71 713	72 228	72 200
World total	250 851	255 568	255 835	256 266	256 845

Source: U.S. Bureau of Mines, Peat, C. Davis, 1985; Energy, Mines and Resources Canada.
[1] Agriculture and fuel uses. [2] Total may not round due to duplication in usage totals.
[e] Estimated; P Preliminary; [r] Revised.

TABLE 5. PRICES[1] IN UNITED STATES, BY TYPE OF PEAT, 1985

Type	Domestic			Imported[2]
	Bulk	Packaged or bales	Average	Total
		(U.S. dollars per short ton)		
Sphagnum moss	20.48	77.78	56.77	121.18
Hypnum moss	36.90	41.91	41.36	..
Reed-Sedge	24.20	26.45	25.63	..
Humus	13.73	22.13	15.52	..
Other	13.64	..	13.64	..

Source: U.S. Bureau of Mines, Peat, C. Davis, 1985.
[1] Prices are f.o.b. mine. [2] Average customs prices.
.. Not applicable.

Phosphate

G.S. BARRY

Naturally occurring rock deposits are the most common source of phosphorus; other sources are bones, guano, and some types of iron ores that yield by-product basic slag containing sufficient phosphorus to warrant grinding and marketing.

Phosphate rock contains one or more suitable phosphate minerals, usually calcium phosphate, in sufficient quantity for use, either directly or after beneficiation, in the manufacture of phosphate products. Sedimentary phosphate rock, or phosphorite, is the most widely used phosphate raw material. Apatite, which is second in importance, occurs in many igneous and metamorphic rocks.

Phosphate rock is graded either on the basis of its P_2O_5 equivalent (phosphorus pentoxide) or its $Ca_3(PO_4)_2$ content (tricalcium phosphate of lime or bone phosphate of lime - TPL or BPL). For comparative purposes, 0.458 unit P_2O_5 equals 1.0 unit BPL, and 1 unit of P_2O_5 contains 43.6 per cent phosphorus.

Approximately 80 per cent of world phosphorus production goes into fertilizers; other products which require the use of phosphorus include organic and inorganic chemicals, soaps and detergents, pesticides, insecticides, alloys, animal-food supplements, motor lubricants, ceramics, beverages, catalysts, photographic materials, and dental and silicate cements.

In 1986, world phosphate production was estimated at 150 million t, about 7 million less than in 1985, in spite of the increase predicted in early 1986. Western World consumption and production was in balance. Stocks held by major western world producers were 23.5 million t at the end of September 1986 compared to 23.9 million t at the end of September 1985. Significantly, there were small production and delivery increases in all phosphate producing and exporting countries except the United States. This country produced 7 million t less than in 1985, again acting as a swing producer in times of oversupply.

World exports of phosphate rock were 46.2 million t in 1985 and are expected to drop to approximately 43 million t in 1986. Imports dropped significantly in Western Europe, particularly in France. There was also a large decrease in Canada. Imports in Asia were slightly higher, led by India, Indonesia and the Philippines.

OCCURRENCES IN CANADA

Known Canadian deposits are limited and fall into three main categories: apatite deposits within Precambrian metamorphic rocks located in eastern Ontario and southwestern Quebec; apatite deposits in some carbonate-alkaline complexes (carbonatites) in Ontario and Quebec; and Late Paleozoic - Early Mesozoic sedimentary phosphate rock deposits in the southern Rocky Mountains. Phosphatic mineralization was also reported in the layered rocks of the Athabasca series.

The deposit of greatest economic significance is the Kapuskasing (Cargill) phosphate deposit, where early studies indicated the presence of about 60 million t of ore grading 20.2 per cent P_2O_5. The property was optioned by Sherritt Gordon Mines Limited in 1979 from International Minerals & Chemical Corporation (Canada) Limited (IMCC). The option was exercised in December 1983. Additional drilling, test pits and bulk sample pilot plant testing confirmed the technical viability of this deposit. It has been determined that the deposit contains higher grade sections totalling 22 million t grading 27 per cent P_2O_5. The best part of the deposit, contains 6 million t grading 33 per cent P_2O_5. This ore will need only minor concentration.

Another important carbonatite deposit was discovered by Shell Canada Limited near Martison Lake north of Hearst, Ontario. In December 1982, the deposit was purchased by New Venture Equities Ltd. which formed a 50-50 joint venture with Camchib Mines Inc. for further exploration and development. Camchib Mines Inc. is wholly-owned by Campbell Resources Inc. The joint venture continued with detailed, fill-in

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drilling on the property and announced in August 1983, that higher grade zones of the deposit contained 57 million t grading 23 per cent P_2O_5. A $1.2 million additional drilling program was completed in 1984.

In July 1984, Sherritt Gordon Mines Limited, Campbell Resources Inc. and New Venture Equities Ltd. combined forces in a 50/25/25 joint venture on the two phosphate properties at Cargill and Martison Lake. The joint venture proceeded with a stripping program on the Cargill orebody and removed about 2 000 t of residuum for testing in a pilot field concentrator. About 600 t of high grade concentrate was produced and is stored on site for eventual further bench scale testing in a phosphoric acid plant. Pre-feasibility studies indicate that the Cargill deposit is not economic under current international very low phosphate rock prices. It will become the basis for a viable mining operation of approximately 500 000 t per year of 84 to 86 BPL rock in the 1990s when supply and demand are in balance and phosphate rock prices have improved substantially. At present, both properties are on hold pending improved economic conditions. The Ontario Ministry of Northern Development and Mines commissioned in the fall of 1986 a phosphate market and development opportunity study which will be completed in early 1987.

CANADIAN PHOSPHATE INDUSTRY

Phosphate Rock. In 1985, Canada imported 2.64 million t of phosphate rock; for the first nine months of 1986 imports decreased by 11 per cent. The economic recession in the agricultural sector combined with the closures of two phosphatic fertilizer plants were responsible for the low import levels. A little over three-quarters of the phosphate rock is imported for fertilizer production and the remainder for elemental phosphorus.

About 70 per cent of Canada's imports of phosphate rock from the United States have been from Florida since the late 1970s. The remainder was from the western states. Purchase practices, which include commercial factors as well as the characteristics of rock used by the fertilizer plants, point to the continuation of this pattern of supply for at least a few years. Lately, the industry in western Canada has been experimenting with the usage of phosphate rock from Morocco, Togo and Jordan. Very low world shipping costs make this rock competitive with imports from the United States.

In 1986, Belledune Fertilizer, a division of Noranda Inc., produced, from rock imported from Florida, approximately 140 000 t of diammonium phosphate (DAP) at its New Brunswick fertilizer plant. The plant was shut down during June, July and August to complete a conversion from the dihydrate to the hemihydrate process. The hemidydrate process, under license from Norsk-Hydro Fertilizers permits substantial energy savings and also results in an excellent DAP product. The plant was designed by Société de Prayon and built by Wellman Power Gas Inc. The cost of the conversion was approximately $4 million.

International Minerals & Chemical Corporation closed its Port Maitland fertilizer plant at the end of June 1984 for an indefinite period (currently the plant is "mothballed"). High transportation costs of rock from Florida and sulphur from Alberta made it more economic for the company to import finished fertilizers for distribution to its customers.

C-I-L Inc. operated its Lambton Works phosphoric acid plant, near Courtright, only for the first half of the year. The plant used phosphate rock purchased from Florida producers. Production of monoammonium phosphate (MAP) and DAP combined was approximately 45 000 t. The company closed the plant permanently at the end of June 1986 and intends to scrap it. Part of the plant will be used to neutralize phosphogypsum pond water with lime over a period of three years.

Cominco Ltd. produced a total of approximately 255 000 t of phosphatic fertilizers in 1986 (MAP and 16-20-0) from its two plants in British Columbia. Phosphate rock was imported from Utah and from its own small underground mine in Montana. The company shut down its Trail plant for four weeks in August. The modernization of the Trail phosphoric acid plant was completed. The Kimberley plant was down in June, July and August and was shut down again in mid November, and will not reopen until early 1987.

Esso Chemical Canada operated its Redwater, Alberta phosphoric acid plant much below capacity in 1986. The company ceased a tolling arrangement with Sherritt Gordon Mines Limited at the beginning of 1986. The plant was shut down between August 14 and September 30, 1986.

Western Co-operatives Fertilizers Limited operated its Calgary plant throughout the year except for a closure of its No. 1 phosphoric acid plant from September 12 to October 3 and of its No. 2 plant from September 5 to October 17. The ammonium phosphates plant was closed for two weeks in September. Until August 1986, the company used phosphate rock from stocks from the closed Conda mine (Idaho) and operated on Florida rock for the remainder of the year. The Western Co-op plant produced slightly over 250 000 t of ammonium phosphate fertilizers, mainly MAP. The mothballed Medicine Hat plant will be scrapped as the company announced the closure of its remaining nitrogen plant at the same locality, as of April 1987.

Sherritt Gordon Mines Limited terminated its tolling arrangements for phosphatic fertilizers with Esso Chemical Canada, as of the beginning of 1986 and operated its own phosphoric acid plant throughout the year, except for a two week shutdown in September. The company shipped considerably less product in 1986 than in 1985.

Elemental phosphorus. Tenneco Canada Inc., ERCO Division, operates two thermal reduction plants in Canada where elemental phosphorus is produced by the smelting of a mixture of phosphate rock, coke and silica. One tonne of phosphorus requires the input of about 10 t of phosphate rock (60 to 67 per cent BPL), 2 t of coke and 3 t of silica. Energy consumption is about 13 000 kWh per t of phosphorus.

Tenneco has plants at Varennes, Quebec with a 22 500 tpy capacity (P_4) and at Long Harbour, Newfoundland with an effective capacity of about 60 000 tpy. The elemental phosphorus production from Long Harbour is in a large part destined for Albright & Wilson, Inc. derivative plants in Europe, with some export to the Far East. A proportion was sent to Port Maitland, Ontario to supplement supplies from Varennes, Quebec. The Long Harbour plant operated at between 75 per cent and 80 per cent capacity. It closed for three weeks in July for maintenance.

The Varennes plant operated at approximately 80 per cent capacity. One of two of its main furnaces was closed for two months in the summer. The two small by-product "mud" furnaces operated with good results. All of the output from Varennes is used domestically in the Ontario plants.

The two Tenneco phosphorus plants use between 600 000 and 700 000 t of Florida phosphate rock annually. Since the low-grade phosphate rock acceptable for thermal reduction cannot be used by the fertilizer industry, it can be purchased at relatively lower prices (per P_2O_5 unit value).

The elemental phosphorus (P_4) produced at Varennes is shipped to two Tenneco plants, one at Buckingham, Quebec and the other at Port Maitland, Ontario. At Buckingham, about 9 000 tpy of P_4 is used to produce technical and food grade phosphoric acid (95 per cent H_3PO_4) and 1 000 t to produce amorphous red phosphorus.

Tenneco's Port Maitland plant operates on phosphorus from Varennes and Long Harbour, using between 13 000 and 14 000 tpy. In 1986, however, approximately 10 per cent of phosphorus was imported from the United States. Elemental phosphorus is all converted to technical grade phosphoric acid and derivatives.

Coproducts of elemental phosphorus are ferrophosphorus, carbon monoxide and calcium silicate slag. Ferrophosphorus contains 20 to 25 per cent phosphorus and is used by the steel industry as a direct source of phosphorus needed for producing certain types of steel.

Phosphate fertilizers. Six of the operating Canadian plants produce wet phosphoric acid by the dihydrate process in which 28 to 30 per cent P_2O_5 acid is the principal product and gypsum the waste product. One plant was converted to a hemihydrate operation. At present, there is no use for the gypsum and it accumulates in large settling ponds in New Brunswick where it is disposed of in the sea.

Canadian dihydrate phosphoric acid plants are designed to operate on phosphate rock which grades between 69 and 72 per cent BPL (31.1 to 33.0 per cent P_2O_5). The first stage of acid production, which is digestion and filtration, produces "filter acid" grading 28 to 30 per cent P_2O_5. This product is then upgraded by evaporation to about 40 to 44 per cent acid for most in-plant uses, or to 52 to 54 per cent P_2O_5 for commercial sales or specialized uses. The evaporation step is energy intensive and the provenance of sulphuric acid has a bearing on energy consumption. Plants using elemental sulphur as the source of in-plant sulphuric acid production have their evaporation energy requirements met by heat generated in the sulphuric acid plants, since the process is exothermic, (i.e., 1 t of sulphur has a BTU content equivalent to about two barrels of oil). Plants using commercial sulphuric acid, (e.g., produced from SO_2 smelter gases) have to generate vapour requirements with natural gas or coal-fired boilers. To balance energy requirements, an efficient dihydrate WPA plant could theoretically operate using elemental sulphur for 70 to 75 per cent of its requirements and purchase sulphuric acid for the remainder.

Most phosphate rock contains uranium. It is found in small enough quantities not to present any problems for fertilizer production. In Canada, Earth Sciences Inc. started a uranium recovery plant in Calgary in 1980. It treats phosphoric acid from the adjoining plant of Western Co-operative Fertilizers Limited and returns the acid to the owner. The plant was placed on standby in November 1981. The plant underwent major modifications during 1982 and 1983 and was reopened in May 1983. Since that time, the plant has operated continuously until September 1986, when it was closed for process equipment additions. It reopened in mid-December. The recovered yellow cake is shipped to British Nuclear Fuels Limited in the United Kingdom for refining and then returned to the United States.

Capacity of Canada's phosphoric acid plants is expressed in 100 per cent P_2O_5 equivalent and the total operating annual capacity at the end of 1986 was 634 000 t. A plant of some 90 000 t of capacity was closed at Courtright in 1986 and will be dismantled; another with 65 000 t of capacity at Medicine Hat, Alberta, is being dismantled and one of 118 000 t of capacity at Port Maitland is mothballed.

Efficient plants can consistently operate at 90 to 95 per cent nameplate capacity. Most Canadian plants, gauge their annual production levels to corporate marketing strategies and fertilizer demand forecasts. At times when agricultural demand is low, Canadian production capacities are seriously underutilized. The recovery of P_2O_5 from phosphate rock, i.e., the efficiency of conversion, varies from 88 to 94 per cent.

All phosphoric acid plants in Canada are integrated to produce phosphatic fertilizers, mainly ammonium phosphates. Ammonium phosphates are produced by a neutralization reaction of phosphoric acid with ammonia and, depending on the proportions of the original constituents, either diammonium phosphate (DAP) (18-46-0) or monoammonium phosphate (MAP) (range from 11-48-0 to 11-55-0) are produced. Another common grade particularly in the west is the 16-20-0.

Canadian fertilizer plants produce annually between 800 000 and 900 000 tpy of MAP, between 150 000 and 200 000 t of DAP and about 150 000 t of other ammonium and ammonium nitrate phosphates.

Calcium Phosphate. Cyanamid Canada Inc. produced dicalcium phosphate (18.5 per cent phosphorus) at its Welland fertilizer plant. The company used to purchase its acid from IMC's Port Maitland plant, but from October 1984 until July 1986 when the plant was sold to Occidental Corp. and shut down permanently, it imported it from the United States.

Calcium phosphates are used mainly for supplementing the calcium and phosphorous content of animal and poultry feedstocks.

WORLD DEVELOPMENTS

World phosphate rock production in 1986 was estimated at 149.4 million t, a decrease of 1.6 per cent from 151.9 million t in 1985. Western world production was estimated at 103 million t.

The stagnation in production was mainly attributed to very low deliveries in the United States. Most of the smaller world producers marginally increased their production levels, but the world phosphate rock industry as a whole still suffers from a large excess of capacity and prices remain very weak.

The United States phosphate rock industry had a capacity of 64.7 million t and operated at 63 per cent capacity at mid-year 1986. The U.S. Bureau of mines reported that near the end of the year, there were 25 operating phosphate rock mines eight of which were temporarily closed in the United States. Six major mines are closed in Florida. The combined capacity of Florida and North Carolina is 53.8 million tpy. These mines operated at about 65 per cent capacity.

The U.S. Bureau of Mines reported in 1986 that mines in the Western States, Tennessee and North Carolina have sufficient reserves to permit operation well into the next century. In Florida, however, insufficient high grade reserves, combined with unfavourable mine economics, continuingly low rock prices and environmental factors led to an estimate of rapid declines in existing capacity as follows: 48.3 million t in 1986; 40.7 million t in 1993; 31.6 million t in 1995 and 19.8 million t in the year 2000. Low grade reserves are not taken into account. Some experts, however, predict that some 3 to 11 million t of new capacity may be developed in Florida between 1995 and 2005, under much more favourable conditions than those which prevail today. The Chevron Chemical Company is currently expanding its Vernal, Utah mine from 0.7 to 1.2 million t to provide feed stock for its newly commissioned fertilizer complex in Wyoming.

A survey carried out by The International Fertilizer Industry Association, indicated that any decline in production which Florida would have to face well into the mid-1990s could be easily compensated by increases in countries of Northwest Africa and the Near East. Thus a significant expansion potential exists in Morocco at the Khouribga and Yousoufia mines along with a possibility of a complete rehabilitation of Bu Craa. In Tunisia, expansions of existing mines are still possible. There is also the possibility of a new mine at Kef Eddour. In the Near East, Israel will expand its mining capacity by up to 2 million t and Jordan is likely to bring a new mine on stream at Shidiyah. New mining capacity will also be added in Egypt, Mexico, Peru and Brazil. In Finland, Kemira Oy plans to put into production the Sokli deposit. Christmas Islands Mining Company will continue operating for the next 5 to 7 years, rescinding a decision to close the mine at the end of 1986.

PRICES

Most phosphate rock is purchased under producer-consumer negotiated prices which differ from listed prices in consideration of volume, transportation conditions and local competitive conditions. Phosrock Ltd., a Florida-based marketing organization represents about two-thirds of the producers for export markets.

The average unit price of phosphate rock sold or used in the United States for domestic consumption was $US 21.87/t f.o.b. mine in the fertilizer year ending June 30, 1986 while that of exported rock was $US 27.50/t. The U.S. Bureau of Mines reported Florida and North Carolina prices for the same period as follows:

% BPL		$US/t	
	Domestic	Export	Average
+74	31.51	41.99	36.07
72-74	20.15	28.74	24.61
70-72	19.69	24.54	22.70
66-70	21.68	22.19	21.76
60-66	20.19	21.09	20.26
-60	21.50		21.50

OUTLOOK

The outlook for 1987 is for a continuation of demand at the current low levels, ample supply and low prices. A further slight decline in prices is still a possibility. Some industry experts forecast a steady growth in demand from 1988 onwards but price improvements will be minimal until supply and demand approach a balance, which may not be before the 1990-92 period. A leading consulting firm forecasts a rapid increase in price after that interval to approximately $US 45.00/t in 1995 (basis 70 per cent BPL) from the current $US 27.50 f.o.b. vessel Tampa. At prices approaching those of the mid-1970s, a Canadian phosphate deposit such as Cargill in Ontario could become a viable development.

Long term growth rates for phosphate rock consumption were forecast until recently in the range of 2.5 to 3.5 per cent per year. Some analysts specializing in phosphate markets now forecast much lower growth rates for the world, at 1.7 to 2.0 per cent per year. A major departure from former forecasts is a downward revision in growth potential in the United States and EEC countries. Nevertheless, even at the lower growth rate of 2 per cent, the world phosphate rock demand would increase from 143 million t in 1985 to 205 million t in 1995 and after allowing for major expansions in Africa, it still leaves an output requirement of about 50 million t from the United States.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(per cent)		
CANADA					
93100-2	Phosphate rock	free	free	free	free
66345-1	Defluorinated calcium phosphates for use in the manufacture of animal or poultry feeds	free	free	free	free
93103-1	Calcium phosphate, dibasic	free	free	free	free
93103-2	Calcium phosphate, disintegrated, calcined; thermophosphates; fused phosphates; superphosphates	free	free	free	free
92840-1	Phosphites; hypophosphites and phosphates ;	10	12.8	25	8.5
	sodium phosphate, dibasic, and monobasic, pharmacopoeial, tribasic, commercial grade; sodium pyrophosphates, normal, other than A.R., C.P. and pharmacopoeial grades; sodium tripolyphosphate (temporary rate reduction 3/06/80 to 30/06/87)	free	12.8	25	free
92840-2	Dicalcium phosphate	1.9	1.9	25	1.0
	(temporary rate reduction 3/06/80 to 31/12/86)	free	1.9	25	free
93100-1	Fertilizers; goods for use as fertilizers	free	free	free	free
93105-1	Ammonium phosphates	free	free	free	free

MFN Reductions under GATT (effective January 1 of year given)	1986	1987
	(per cent)	
92840-1	12.8	12.5
92840-2	1.9	free

UNITED STATES, Customs Tariffs (MFN)			
421.18	Sodium phosphate containing over 45 per cent water	2.6	2.5
421.22	Pyrophosphates	3.9	3.7
606.33	Ferrophosphorus	2.9	2.4

Sources: The Customs Tariff, 1986, Revenue Canada; Customs and Excise. Tariff Schedules of the United States Annotated (1986), USITC Publication 1775; U.S. Federal Register, Vol. 44, No. 241.

TABLE 1. CANADA, PHOSPHATE ROCK IMPORTS, 1984-86, AND CONSUMPTION, 1983-86

	1984		1985		1986P	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Imports						
United States	3 169 613	120,852	2 579 871	109,620	2 287 454	94,971
Togo	-	-	35 800	2,336	36 722	2,645
Morocco	-	-	22 000	437	63 580	1,921
Total	3 169 613	120,852	2 637 671	112,413	2 387 756	99,537

	1983	1984	1985	1986[e]
	(tonnes)			
Consumption[1]				
Eastern Canada	1 132 020	1 222 000	945 500	919 700
Western Canada	1 159 151	1 810 300	1 831 700	1 571 000
Total	2 291 171	3 032 300	2 777 200	2 490 700

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Breakdown by Energy, Mines and Resources Canada.
[e] Estimated; - Nil.

TABLE 2. CANADA, PHOSPHATE FERTILIZER SHIPMENTS, 1980-86[1]

	1980/81	1981/82[r]	1982/83	1983/84	1984/85	1985/86
	(tonnes P_2O_5 equivalent)					
Domestic markets:						
Atlantic provinces	24 481	26 261	29 443	24 965	26 894	20 360
Quebec	28 610	34 915	43 308	37 835	27 990	23 865
Ontario	82 496	71 033	71 959	79 160	52 843	39 287
Manitoba	97 529	75 239	81 907	90 529	92 092	90 354
Saskatchewan	135 534	144 998	153 784	195 170	182 017	184 306
Alberta	149 116	152 906	157 010	161 185	170 943	153 523
British Columbia	13 308	8 998	10 970	11 311	11 940	10 951
Total Canada	531 074	514 350	548 381	600 155	564 719	522 646
Export markets:						
United States	194 565	141 411	82 478	65 790	71 403	46 763
Offshore	77 328	20 305	715	4 652	12 743	17 021
Total exports	271 893	161 716	83 193	70 442	84 146	63 784
Total shipments	802 968	676 066	631 574	670 597	648 865	586 430

Source: Canadian Fertilizer Institute.
[1] Fertilizer year: July 1 to June 30; not 100 per cent industry coverage.
[r] Revised.
Note: Totals may not add up due to rounding.

TABLE 3. CANADA, PHOSPHATE FERTILIZER PLANTS

Company	Plant Location	Annual Capacity	Principal End Products	Source of Phosphate Rock	Basis for H_2SO_4 Supply for Fertilizer Plants
		(tonnes P_2O_5 eqivalent)			
Eastern Canada					
Belledune Fertilizer div. of Noranda Inc.	Belledune, N.B.	150 000	am ph	Florida	SO_2 smelter gas
C-I-L Inc.	Courtright, Ont.	90 000[1]	am ph	Florida	SO_2 smelter gas, pyrrhotite roast and waste acid
		240 000			
Western Canada					
Cominco Ltd.	Kimberley, B.C.	86 700	am ph	Montana and Utah	SO_2 pyrite roast
	Trail, B.C.	77 300	am ph	Utah	SO_2 smelter gas
Esso Chemical Canada	Redwater, Alta.	370 000	am ph	Florida	Sulphur
Sherritt Gordon Mines Limited	Fort Saskatchewan, Alta.	50 000	am ph	Florida	Sulphur
Western Co-operative Fertilizers Limited	Calgary, Alta.	140 000	am ph	Idaho Florida	Sulphur
		724 000			
Canada: installed capacity:	mid 1986	964 000			
historical capacity:					
end of 1983		1 031 000			
end of 1984		913 000			
end of 1985		788 000			
end of 1986		698 000			

P_2O_5 equivalent - Phosphorus pentoxide equivalent; am ph Ammonium phosphates.
[1] Shutdown as of the end of June 1986.

TABLE 4. CANADA, TRADE IN SELECTED PHOSPHATE PRODUCTS, 1984-86

	1984		1985		1986P	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Imports						
Calcium phosphate						
United States	53 702	23,155	93 573	33,955	111 205	40,668
Other countries	981	398	210	264	291	372
Total	54 683	23,553	93 783	34,219	111 496	41,040
Fertilizers:						
Normal superphosphate, 22 per cent or less P_2O_5						
United States	27	4	14 001	1,102	190	25
Israel	14 043	1,498	1 108	217	-	-
Netherlands	-	-	-	-	-	-
Total	140 070	1,502	15 109	1,319	190	25
Triple superphosphate, over 22 per cent P_2O_5						
United States	57 724	11,659	71 968	14,247	93 284	21,280
France	-	-	-	-	2 999	728
Total	57 724	11,659	71 968	14,247	96 283	22,008
Phosphatic fertilizers, nes						
United States	266 980	78,435	359 399	94,707	342 309	90,726
Belgium-Luxembourg	1 105	622	1 043	578	625	382
Israel	182	111	455	235	131	74
Netherlands	58	21	-	-	-	-
Other countries	58	22	4	8	2	2
Total	268 383	79,211	360 901	95,529	343 067	91,184
Chemicals:						
Potassium phosphates						
United States	1 577	2,222	1 494	1,886	3 210	3,242
France	163	177	234	233	245	291
Israel	174	198	265	241	191	244
Netherlands	35	42	34	39	1	2
West Germany	5	5	47	56	44	66
Total	1 954	2,644	2 074	2,456	3 732	3,885
Sodium phosphate, tribasic						
United States	381	316	350	222	337	328
France	252	95	285	90	132	46
Belgium-Luxembourg	-	-	-	-	45	24
Netherlands	93	36	80	33	148	67
People's Republic of China	243	102	258	79	403	132
Sweden	-	-	-	-	14	11
Total	969	549	973	424	1 079	610
Exports						
Nitrogen phosphate fertilizers, nes						
United States	182 163	40,362	168 074	38,244	133 441	29,683
India	20 999	5,555	-	-	-	-
Australia	-	-	-	-	19 936	6,111
Costa Rica	2 929	887	20	7	10 479	2,449
Jamaica	7 184	2,123	3 410	911	4 153	1,028
Other countries	7 986	2,043	20	6	135	33
Total	221 261	50,970	171 524	39,168	168 144	39,304

Source: Statistics Canada.
P Preliminary; - Nil; nes Not elsewhere specified.

TABLE 5. WORLD PHOSPHATE ROCK PRODUCTION, 1982-85

	1982	1983	1984	1985e
	(000 tonnes product)			
WORLD TOTAL	**122 913**	**136 685**	**152 122**	**157 036**
West Europe	**389**	**538**	**716**	**734**
Finland	232	381	477	510
Sweden	131	107	128	187
Turkey	26	50	96	37
France	15	12	15	-
East Europe	**27 200**	**28 500**	**31 900**	**32 200**
U.S.S.R.	27 200	28 500	31 900	32 200
North America	**37 414**	**42 573**	**49 197**	**50 835**
United States	37 414	42 573	49 197	50 835
Central America	**379**	**436**	**375**	**549**
Mexico	379	436	375	549
South America	**2 779**	**3 229**	**3 896**	**4 249**
Brazil	2 732	3 208	3 855	4 214
Colombia	18	18	28	23
Peru	29	3	13	12
Africa	**29 987**	**34 159**	**35 967**	**33 732**
Algeria	946	893	1 000	1 208
Egypt	708	647	1 043	1 074
Morocco/Sahara	17 754	20 107	21 245	20 245
Senegal	975	1 522	1 912	1 781
South Africa	3 173	2 742	2 585	2 421
Togo	2 035	2 081	2 696	2 452
Tanzania	-	20	15	21
Tunisia	4 196	6 016	5 346	4 530
Zimbabwe	120	133	125	..
Asia	**23 251**	**23 529**	**29 072**	**33 195**
China	11 728	12 830	14 210	12 000
Christmas Island	1 328	1 066	1 259	1 200
India	560	787	800	748
Iraq	363	1 199	1 000	1 000
Israel	2 711	2 969	3 312	4 076
Jordan	4 431	4 749	6 263	6 067
North Korea	500	500	500	500
Syria	1 455	1 229	1 514	1 270
Vietnam	160	170	200	250
Sri Lanka	15	15	14	17
Oceania	**1 594**	**1 705**	**1 374**	**1 542**
Australia	235	21	15	34
Nauru	1 359	1 684	1 359	1 508

Sources: Phosphate Rock Statistics, 1983, ISMA Ltd.; United States Bureau of Mines (USBM), Mineral Commodity Summaries 1985.
e Estimated; - Nil; .. Not available.
Totals may not add up due to rounding.

Platinum Metals

G. BOKOVAY

For the more important of the six platinum group metals (PGMs) - which include platinum, palladium, rhodium, ruthenium, iridium and osmium - 1986 brought sharply higher prices. While increasing industrial demand contributed to the strong performance of platinum and rhodium in the first half of the year, a surge of speculative buying in the third quarter of 1986 propelled prices upward, with rhodium reaching an all-time high of $US 1,400 per ounce. Although continuing concern over political and labour problems in the Republic of South Africa was the underlying reason for the third quarter price spiral, this fear was compounded by the threat of economic sanctions by a number of western nations and counter-sanctions by Pretoria. While overall palladium supply is less dependent on South African production than other PGMs, prices for this metal also responded to the political developments pertaining to that country.

There are few if any cost efficient substitutes for PGMs in the variety of industrial applications of these materials, but non-speculative demand could decline somewhat as a result of the recent escalation of prices. Should speculative forces continue to exert upward pressure on the market, this trend will continue as industrial consumers move to improve the utilization of the platinum metals and also as recycling increases in importance.

Demand within the important jewellery sector would normally be considered to be price elastic, particularly with platinum at a significant premium to gold, although the strong performance of the Japanese yen has discounted the effect of higher prices to some degree in Japan, the largest market for platinum jewelry.

Despite the possible adverse impact on demand in the event of a sustained period of elevated prices, the short-term outlook is extremely positive. Canada is a relatively small player in the international PGM industry at present but market conditions have stimulated significant exploration in this country. In view of the excellent potential in many areas, as indicated by preliminary findings, Canada should significantly increase its share of total PGM production in the next decade.

CANADIAN DEVELOPMENTS

Platinum group metals are produced in Canada by Inco Limited and Falconbridge Limited as byproducts from the mining and processing of nickel-copper ores. The bulk of the PGMs are recovered from operations in the Sudbury basin, but small amounts are also produced by Inco at Thompson, Manitoba.

The residue from the refining of nickel-copper matte, which contains platinum group metals, is shipped by Inco to its refinery at Acton in the United Kingdom for the extraction and refining of PGMs. Falconbridge ships a nickel-copper matte containing PGMs to its refinery at Kristiansand, Norway.

Canadian production of PGMs in 1986 is estimated at 8 793 kg, compared to 10 534 kg in 1985. Although detailed information is not available, it is likely that in recent years palladium output has been somewhat higher than that for platinum. By virtue of the size of its nickel mining operations, Inco is by far the largest Canadian PGM producer.

Canadian reserves of PGMs are estimated at about 280 million g, of which almost 90 per cent is platinum and palladium in almost equal proportions.

During 1986, one of the most active areas for platinum exploration in Canada centered on Lac des Iles, north of Thunder Bay, Ontario. With what is considered to be one of the largest platinum/palladium prospects outside of South Africa, Madeleine Mines Ltd. announced a major exploration

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program and initiated metallurgical testing on its optioned Lac des Îles deposit. The company's preliminary plans for the site include the development of an open-pit mine with a mining rate of about 3 000 tpd. Madeleine also announced plans to move its idle concentrator from Ste. Anne des Monts, Quebec, to the Lac des Iles area and is also reported to be examining the feasibility of constructing a refinery to process PGM concentrate. Estimated reserves of the Roby zone are in excess of 20 million t grading 5.2 g/t PGM, with a platinum to palladium ratio of 1:7. Other companies active in the Lac des Iles area include American Platinum Inc., Cream Silver Mines Ltd. and Equinox Resources Ltd.

The Marathon, Ontario property of Fleck Resources Ltd. received a serious set-back at the end of 1986 with the announcement by Teck Corporation that it was dropping its option on the prospect after completing a preliminary assessment of economic viability. The deposit is reported to contain 42.5 million t grading 1.78 g/t PGMs, 0.44 per cent copper, 0.034 per cent nickel, 4.5 g/t silver and 0.87 g/t gold.

Another focal point of platinum exploration during 1986 was the Cape Smith Belt in the Ungava region of northern Quebec. Companies active in this area are Oasis Resources Inc., which will finance an exploration program on Falconbridge Limited's Kenty Lake property, Stockmen Energy Ltd., Imperial Platinum Corporation, Cove Energy Corporation and Delaware Resources Corp. Meanwhile, further south, La Fosse Platinum Group Inc. and Ronrico Explorations Ltd. hold a number of exploration leases in the Labrador Trough.

International Platinum Corporation, formerly Silver Lake Resources Inc., currently holds one of the largest land positions in Canada in areas that have significant potential for platinum group metals. During 1986, the company was actively involved in PGM explanation in several provinces. In Saskatchewan, the company with joint venture partners, Lacana Mining Corporation, Murphy Oil Company Ltd., Conventures Limited and the Saskatchewan Mining Development Corporation (SMDC), planned to spend $300,000 during the year on the Wiley Lake platinum prospect. In Manitoba, the company is involved in a joint venture exploration program with BP Selco Inc. at Fox River. In addition, International Platinum Corporation holds property in the Big Trout Lake igneous complex of Ontario, at Lac Sheen in the Belleterre area of Quebec, in the Axelgold layered intrusive of British Columbia, at Kiglapait, Labrador and in the Muskox intrusive complex in the Northwest Territories.

Also active on the Muskox complex, Equinox Resources Ltd., in conjunction with Technigen Platinum Corporation, initiated an exploration program during 1986 including diamond drilling and surface reconnaissance work. Surface samples from the area were reported to contain up to 46.5 g/t of PGM.

In January 1987, Equinox and Technigen announced an agreement to option the R.M. nickel property in Quebec from Corporation Falconbridge Copper. This property is known to contain significant platinum and palladium mineralization. Also in January, Carolin Mines Ltd. in British Columbia announced that it obtained results from tailings samples which indicated platinum values of up to 0.5 oz/t and values for gold of up to 1 oz/t. To confirm these results, further sampling is being planned. The Carolin gold mine, which commenced operations in 1982, has been closed since 1984.

At the end of 1986, it was reported that Gateford Resources Inc. and Macamic Resources Inc. had entered into a joint venture to explore the Reed-Belanger chrome deposit near Black Lake, Quebec.

During the first half of 1986, Noranda Inc. announced that it was bringing a new $3.3 million leach precipitation and metallurgical circuit into production at its CCR refinery in Montreal, to increase gold recovery from 60 000 to 150 000 ounces per month. The new equipment will also improve the recovery of both platinum and palladium.

During 1986, a Calgary company, Canadian Platinum Refineries Inc. announced plans for the construction of a recycling plant to recovery PGMs from autocatalysts and industrial scrap. However, it is not known when the facility will be completed.

WORLD DEVELOPMENTS

The major world producers of platinum group metals are the U.S.S.R., the Republic of South Africa and Canada. Minor producers include Japan (from imported nickel and copper ores and intermediates), Colombia, Finland, United States, Yugoslavia and

Zimbabwe. Estimated 1986 world primary production of PGMs is about 249 million g compared to 247 million g produced in 1985.

The U.S.S.R., one of the largest producers of PGMs in the world, derives these metals principally as byproducts of nickel-copper production. For many years, the U.S.S.R. has exported a significant proportion of its PGM production to the western world and is currently the largest supplier of palladium, iridium and osmium in this market. While overall sales have been relatively stable in recent years, there has been a discernable drop in exports of platinum owing to what is presumed to be an increase in consumption by the Comecon countries.

It is reported that 85 to 90 per cent of Soviet production is produced from six mines in the Noril'sk region of northern Siberia. The U.S. Bureau of Mines estimates that the PGM content of Noril'sk ores is as follows: 25 per cent platinum, 67 per cent palladium and 8 per cent iridium, rhodium, ruthenium and osmium combined.

The other principal source of PGMs in the U.S.S.R., accounting for about 10 per cent of Soviet production, is the Kola Peninsula where PGMs are a byproduct of nickel-copper mining. PGMs are also recovered from placer deposits in the southern Urals, once the major source of U.S.S.R. output. Total Soviet reserves of PGMs are estimated at 6 220 t.

In the Republic of South Africa, the world's other major producer, there are three producers: Rustenburg Platinum Holdings Limited, Impala Platinum Holdings Ltd. and Western Platinum Limited. Unlike production in Canada or in the U.S.S.R., South African PGMs are derived from ores that are mined primarily for their platinum metal content. In addition, South African ores differ significantly from Soviet mineralization in that they have a much higher ratio of platinum to palladium. The bulk of South Africa ores, which come from the Merensky Reef of the Bushveld igneous complex in the Transvaal, are thought to contain precious metals in the following proportion: 59 per cent platinum, 25 per cent palladium, 12.8 per cent other PGMs and 3.2 per cent gold. In addition, these ores also contain appreciable quantities of nickel and copper.

In addition to the Merensky reef, significant PGM reserves also exist in the UG2 (Upper Group Chrome) and Plat Reef zones of the Bushveld complex. While deeper and somewhat more difficult to process, UG2 ore accounts for a small but increasing share of South African production. It is expected that this trend will continue as easily mined areas of the Merensky reef are exhausted.

The UG2 zone contains significantly more palladium and rhodium but less platinum than the Merensky reef. The breakdown of the precious metals applicable to the UG2 zone is as follows: 42 per cent platinum, 35 per cent palladium, 12 per cent ruthenium, 8 per cent rhodium, 2.3 per cent iridium and 0.7 per cent gold.

Current South African reserves of PGMs, calculated to a depth of 1 200 m, are estimated at 75 000 t. However, a recent report by the Geological Survey of South Africa suggests that PGM reserves in that country may be somewhat larger in view of recent geological studies, which indicate that the Bushvelt complex extends significantly beyond previously established boundaries.

Despite significant labour problems experienced by the platinum metals industry at the beginning of the year, it is reported that South African PGM production in 1986 increased by approximately 5 per cent to over 121 t. At the end of 1986, most mines were thought to be operating at or exceeding full capacity.

Rustenburg, which is the largest South African producer, operates three major mines in the Bushvelt complex while its wholly owned subsidiary, Atok Platinum Mines (Proprietary) Limited, operates one smaller mine. Capacity of the Rustenburg operations is estimated at 2.1 million ounces of PGMs per annum. In its annual report for the fiscal year ending June 30, 1986, the company reported that its mines were operating satisfactorily with the exception of its Union Section where tonnage and head grade were being adversely affected by unexpected geological problems. However, the company also reported that an increased tonnage of UG2 ore was mined and processed at this location during the year.

In early-December, an explosion at one of the company's smelters resulted in the loss of 25 per cent of Rustenburg's smelting capacity. While the smelter could be out of commission for up to three months, the company expects that overall output of PGMs will be unaffected.

PGMs produced by Rustenburg are recovered at the Wadeville refinery in Gemistown, South Africa and another at Royston in the United Kingdom. Both plants are managed by Matthey Rustenburg Refiners (Pty) Limited, which is jointly owned by Rustenburg Platinum and Johnson Matthey Public Limited Company. The Wadeville refinery is owned by Rustenburg while the Royston facility is owned by Matthey Rustenburg.

In June 1986, Rustenburg announced that it will build a new PGM refinery in Bophuthatswana to replace the Wadeville and Royston facilities. The new plant, which is expected to come on-stream in 1989, will utilize the "Solvex" process which has been successfully utilized in a large-scale pilot plant at the Royston refinery. While primary PGM production at Royston will be discontinued, it is expected that the plant will be operated as a secondary recovery facility.

Impala Platinum, South Africa's second largest PGM producer, is thought to have an annual capacity of about 1.7 million ounces. While the company does not report production statistics, Impala estimated that it lost the equivalent of 45 million Rand ($US 17 million) as a result of labour problems experienced in early-1986, during which the company dismissed 23,000 workers. Notwithstanding this loss of production, the company reported a 33 per cent increase in net profit, to 192.7 million Rand, for the year ending June 30, 1986. It has also been reported that the company made up for any loss of production by drawing down its PGM inventories.

Despite a Canadian government policy supporting a voluntary ban on new investment in South Africa, Falconbridge Limited announced in November that it had purchased a 24 per cent share of Western Platinum Limited from Mobil Corporation's Exploration and Producing Division raising its stake in the company to 49 per cent. This controversial 24 per cent interest in Western Platinum Limited was originally owned by Falconbridge but was transferred to Superior Oil Company in 1970. Falconbridge stated that its repurchase of Western Platinum shares was made in order to protect its investment in the company and more specifically to maintain representation on Western's board of directors.

In February 1987, Falconbridge announced that it had sold Western Platinum for $US 75 million. The company did not identify the purchaser, although Lonrho plc, the other principal shareholder of Western Platinum, was mentioned in the press as possible buyer.

In late-1986, Western Platinum officially opened its new base-metal refinery near Brits in the western Transvaal. The residue, which contains PGMs and gold, is shipped to the company's Brakpan precious metals refinery. Prior to the completion of the new base-metal facility, PGMs were sent to Falconbridge's refinery in Norway in matte and then returned to South Africa as sludges.

In June 1986, Gold Fields of South Africa Ltd. announced that it was proceeding with the development of its Northam platinum project. The new mine, which is located southeast of the Amandelbult section of Rustenburg Platinum, will cost an estimated 559 million Rand. The mine is scheduled to begin production in 1991. Initial output is expected to be about 250 000 ounces of platinum per annum. Reserves of Merensky reef ore at the site are estimated at 163 million t grading 10.1 g/t PGMs plus by-product gold. Although the company has no immediate intention to mine the UG2 reef, accessible reserves at the Northam mine are estimated at 319 million t grading 6.6 g/t. The company is reportedly considering the construction of a PGM refinery on-site but no decision has yet been made.

During 1986, Gold Fields also announced plans to begin platinum exploration in the Molopo River region of southern Botswana. It is reported that the area appears to contain a new limb of the Bushveld igneous complex. South Prospecting International is also active in this area.

Also in South Africa, Rand Mines Ltd. announced in September that it had agreed to participate with Vansa Vanadium S.A. Ltd. in a possible new platinum project near Steelpoort in the eastern Transvaal.

In August 1986, the Stillwater Mining Company, jointly owned by Chevron Resources Company, Manville Corporation and Lac Minerals Ltd., announced that it would proceed with the construction of a mill and other mine support facilities at its Stillwater Complex palladium/platinum development in Montana. While the project itself and the participation of Manville Corporation had been clouded by the insolvency problems of that company, Manville received bankruptcy court approval at the end of July to participate as a partner.

The mine, which is to begin production in 1987, is expected to produce about 25 000 ounces of platinum and 75 000 ounces of palladium per annum, increasing to 50 000 and 150 000 ounces, respectively, by 1991. Proven and probably ore reserves are estimated at 450 000 t grading 22.5 g/t PGM. Although Stillwater had not announced the selection of a refinery for its mine concentrates, it was reported that both Metallurgie Hoboken-Overpelt SA of Belgium and Falconbridge's Kristiansand refinery in Norway were being considered.

With significantly higher prices for platinum group metals, exploration in Australia, like Canada, intensified significantly during 1986. To date, one of the more interesting prospects is the Coronation Hill gold/platinum deposit in the South Alligator area of the Northern Territory. While the issue of aboriginal land claims threatened to block further exploration on the site, the operator of the project, The Broken Hill Proprietary Company Limited, was recently granted permission to proceed. Other partners in this venture include Noranda Pacific Limited and EZ Industries Ltd., a subsidiary of North Broken Hill Holdings Ltd. Noranda Pacific is also involved in a platinum/gold prospect in the Kimberly region of Western Australia. The owner of this property is Strategic Elements of Australia Pty Ltd., a unit of Pact Resources W.L. Also in the Kimberly region, it is reported that Hunter Resources Ltd. is conducting an exploration program at its Loadstone Hill deposit. Hunter Resources is actively exploring a Bushvelt type complex at Munni Munni, Western Australia while a joint venture involving Degussa AG and Pancontinental Mining of Australia Ltd. was active on the Windamurra Complex in the same state. Helix Resources NL and Mumbil Mines NL were reported to be conducting exploration in New South Wales. The properties of Helix Resources are in the Fifield area of the state, the site of limited PGM production at the turn of the century. Elsewhere, Central Pacific Minerals NL and Southern Pacific Petroleum are participating in a joint venture exploration program in Central Queensland, while in Tasmania, both Callina NL and Metals Exploration Ltd. are actively involved in exploration work.

In recent years, the only PGM producer in Australia has been Western Mining Corporation Limited which recovers small quantities of palladium and platinum as a by-product from nickel mining operations. Production in 1984 was estimated at 589 kg.

In early-1986, the U.S. Administration tabled a proposal to sell a portion of the PGM holdings of its National Defence Stockpile. However, because of continuing Congressional disfavour with regard to any disposal, stockpile goals were subsequently frozen at existing levels for at least one more year. Moreover, in view of the escalation of concerns over the future of South African PGM supplies, it is unlikely that PGM stocks will be liquidated in the near future.

As reported a year ago, automobile emission standards in Europe for certain models are scheduled to take effect in 1988. This market is expected to consume about 55 000 oz per year during the initial phase-in period but this should increase to at least 375 000 oz once standards are adopted by all members of the European Community.

It is expected that all European nations will eventually adhere to established emission standards, but there is still some debate as to the appropriate technology that should be utilized to reach this objective. Most countries will make three-way PGM catalytic converters (capable of removing carbon-monoxide, hydrocarbons and nitrogen oxides) mandatory but the United Kingdom, in particular, has come out in favour of the development of a lean burn engine. Despite recent work on the lean-burn concept, a catalytic converter is still required to meet standards, particularly those for hydrocarbons.

Autocatalyst Recycling

The recycling of spent automobile catalysts represents a potentially significant source of PGMs (an average of over 700 000 oz per annum of platinum and palladium were used for autocatalysts in the United States during the period 1976-85), but it is believed that recovery in 1986 was only 150 000-200 000 oz. While higher PGM prices did stimulate the recycling sector, the process involved in removing, dismantling and collecting automotive converters is marginally profitable at best. Another problem which has hampered the recycling effort in the past, has been that many used converters are refitted on other automobiles. However, a new regulation introduced by the U.S. Environmental Protection Agency in November 1986 should reduce this practice by requiring that used converters be tested before re-use.

At present, the major recyclers in the United States are Texasgulf Inc., A-I Specialized Services and Supplies Inc., The Catalytic Converter Refining Co. and Gemini Industries Inc. Texasgulf, which utilizes a plasma arc furnace at its plant in Alabama to recover PGMs, has a rated capacity to handle 500 000 pounds per month of converter units. However, it was reported that the company was operating the plant in July 1986 at a rate of 700 000 pounds per month. It is reported that the average catalytic converter in the United States contains 0.05 oz platinum, 0.02 oz palladium and 0.005 oz rhodium.

PRICES

Platinum

As a result of continuing concern related to political and labour problems within South Africa, platinum prices climbed steadily through the first half of 1986. This was followed by a period lasting until early-September during which speculative buying, fueled by fears that South Africa would restrict platinum supplies in retaliation for economic sanctions against that regime, resulted in a dramatic surge of price levels. However, during the remainder of the year, platinum prices trended downward as immediate fears over South Africa abated somewhat. This relaxation was reinforced, to some extent, by reports that PGM production in that country was running at or near record levels.

In early-1987, a new round of price escalation was set off by reports of labour unrest in the South African gold mining industry and also because of further weakness of the U.S. dollar.

New York dealer prices for platinum, which averaged $US 364 per ounce in January 1986, increased during the first half of the year, with the average price in July reaching $439.23. After sharp increases through August, peaking at $US 665 in early-September, platinum prices declined during the remainder of the year. The average platinum price for December was $474. For the year as a whole, the average platinum price was $461.59, up considerably from $291.47 in 1985.

According to several reports, demand for platinum in 1986 exceeded platinum mine output for the second year in a row. The deficit for 1986 has been estimated at between 3 and 4.8 t.

Palladium

There was no significant trend in palladium prices during the first half of 1986 but sharp increases occurred during August and September, paralleling those of platinum. Like platinum, palladium prices fell during the remainder of 1986, with prices recovering somewhat in January 1987.

Palladium, which averaged $US 102.43 in January 1986, reached a high of $151.00 in September before falling throughout the remainder of the year. The average price for December was $116.89. The average New York dealer price for 1986 was $115.96 compared to $107.76 in 1985. As for platinum, it was reported that there was a considerable drawdown of palladium stocks during 1986, although actual statistics are not available.

Falling oil prices and the Chernobyl nuclear disaster were expected to provide impetus for increased Soviet sales to the west in 1986 but in fact there appears to have been only a modest increase.

Other PGMs

Lesser known PGMs including rhodium, ruthenium, iridium and osmium, are produced in relatively small amounts. Collectively, this group constitutes about 15 per cent of South African PGM production and about 10 per cent of Canadian output. Unlike platinum and palladium which are principal products in South African production, the other PGMs are all by-products and, as such, their supply is essentially inelastic. With substantial quantities of these metals being sold directly by producers to consumers, the open market is often characterized by thin trading and exaggerated price movements.

Speculative demand for rhodium, whose principal use is in automobile catalysts to control nitrous oxide emissions, increased dramatically during 1985 with the announcement that the European Community would introduce emission regulations beginning in 1988. Since the ratio of platinum to rhodium in "three way" automobile catalysts may be as high as 5:1 compared with Merensky ore ratio in South Africa of 20:1, forecast shortages of rhodium caused prices to skyrocket. While rhodium prices remained high during the first half of 1986, no discernable trend was evident. However, like platinum and palladium, rhodium prices moved sharply higher in August and September, reaching $US 1,400 per ounce. Thereafter, rhodium followed platinum downward, with prices at year end being about $1,100 per ounce.

Ruthenium, which traded during the first half of 1986 in the $70-$80/oz range in what was described as a thin market, recorded some gains during the second half of the year with prices reaching $85 per ounce. By the end of the year, ruthenium prices had fallen off somewhat, with quotations reported in the $75-$80 range.

Iridium prices during 1986 were relatively stable with the bulk of quotations in the $410-$430/oz range. Prices for osmium, the rarest member of the PGM group, slipped significantly during the year, owing to reports of larger metal supplies. From a trading range of $US 850-950 per ounce at the beginning of 1986, osmium prices were reported at $650-$750 at year end.

USES

Platinum group metals are used in a wide variety of applications in pure form and in a host of alloys combining different PGMs alone or with other metals. The diversity of uses reflects their varied and unique attributes which include: chemical inertness and corrosion resistance, special magnetic properties, stable catalytic and thermo-electric properties, excellent reflectivity, stable electrical contact resistance and good high temperature oxidation resistance. The major uses of PGMs are in the automotive, jewelry, chemical, electrical, petroleum and glass industries.

One of the largest uses for PGMs, particularly platinum, is in the production of automobile catalysts. In addition to platinum and palladium, auto catalysts designed to control nitrous oxides as well as carbon monoxide and hydrocarbons, contain rhodium. The production of lead-free gasoline, which is required to avoid poisoning of autocatalysts, also uses PGM catalytic agents. Moreover, the injection of platinum into the combustion chamber of automobile engines is reported to increase fuel efficiency by up to 22 per cent. In the refining industry, PGM catalysts are used in hydrocracking and isomerization applications.

Consumption of PGMs for automobile catalysts is largely in the United States but their use in jewelry, which constitutes the second largest use for platinum, is particularly large in Japan and has also been growing in Europe, especially in the Federal Republic of Germany.

In the chemical industry, PGMs are widely used as catalysts with the most important being platinum, ruthenium and palladium. Important specific applications include the production of nitric acid and hydrogen cyanide. PGMs are also used in the manufacture of equipment that is exposed to highly corrosive environments including anodes used in electrolytic processes for such products as chlorine and caustic soda.

The largest market for palladium is in the electronics industry where it is used in the manufacture of multilayer chip capacitors, resistor networks and electrical contacts. The second most important application and fastest growing market for palladium is in the field of dentistry, where it is used in dental alloys and orthodontic and prothodontic devices. Much of this growth has resulted from the substitution of palladium for higher-priced gold. In the medical field, PGMs are used for a variety of products including hypodermic needles, electrodes, casings for pacemakers and as essential ingredients for certain pharmaceuticals such as cisplatin and the new paraplatin which are effective in the treatment of certain cancers.

Other important applications for PGMs include: themocouples used for high temperature measurement; the manufacture of glass, glass fibre and synthetic fibres; permanent magnets; and catalytic applications in the pharmaceutical and food processing industries.

One potential use, which could represent a major new market for platinum, is in the production of fuel cells. In this regard, it has been suggested that 13 per cent of Japanese electricity requirements could be provided by such cells by the year 2000.

In addition to uses by industry or in the manufacture of jewelry, there has been a rapid increase in the production of platinum coins, wafers and small bars in recent years in response to growing investment demand. The one ounce Isle of Man noble, first introduced in 1983, is the only platinum bullion coin currently being produced in the world.

In December 1986, the Montreal Exchange announced that it was initiating the trading of platinum certificates which, unlike more common platinum investments, do not require the purchaser to take delivery of the metal.

OUTLOOK

In view of the volatile political situation which is expected to persist in South Africa, investment/speculative demand for platinum is likely to continue to expand in 1987 and keep the price at $US 500 per ounce or higher.

Although overall demand for platinum is expected to increase in 1987, industrial usage may actually fall. The European auto catalyst market will grow significantly as emission regulations begin to take affect but it is expected that U.S. car sales will decline. In addition, it is expected that the important petroleum refining and chemical industries in the United States will remain somewhat depressed.

Despite a somewhat subdued forecast for industrial consumption in 1987, the long-term outlook remains positive with a 3.0-3.5 per cent average annual rate of growth rate predicted for the next decade. The major growth area will be the autocatalyst market and particularly that in Europe.

Demand for palladium in the important electronics sector, which fell somewhat in 1985, increased significantly in 1986 and should continue to grow in 1987. It was reported in November 1986 that a new palladium-based connector coating, which permits manufacturers to significantly reduce gold usage in electronic applications, had opened up enormous new market opportunities for palladium. In addition, the large market for palladium in dentistry should also continue to expand.

New and stricter environmental controls on automobile emissions of nitrogen oxide expected in the next decade will keep rhodium prices at or near recent highs despite efforts to increase the efficiency of rhodium utilization.

Until such time as new platinum mines are developed in Canada, Canadian production of platinum metals will remain closely tied to nickel output. As such, Canadian output of PGMs in the near-term will continue near production levels achieved in recent years.

TARIFFS

Item No.	British Preferential	Most Favoured Nation	General	General Preferential
		(%)		
CANADA				
36300-1 Platinum wire and platinum bars, strips, sheets or plates; platinum, palladium, iridium, osmium, ruthenium and rhodium, in lumps, ingots, powder, sponge or scrap	free	free	free	free
48900-1 Crucibles of platinum, rhodium and iridium and covers therefore	free	free	15	free
UNITED STATES (MFN)				
601.39 Precious metals ores		free		
605.02 Platinum metals, unwrought, not less than 90 per cent platinum		free		

MFN Reductions under GATT (effective January 1 of year given)	1986	1987
605.03 Other platinum metals, unwrought	9.7	8.2
605.05 Alloys of platinum, semi-manufactured, gold-plated	11.9	10.0
605.06 Alloys of platinum, semi-manufactured, silver-plated	7.2	6.5
605.08 Other platinum metals, semi-manufactured, including alloys of platinum	9.7	8.2
644.60 Platinum leaf	9.7	8.2

Sources: Customs Tariff, 1986, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated (1986), USITC Publication 1775; U.S. Federal Register, Vol. 44, No. 241.

TABLE 1. PLATINUM METALS, PRODUCTION AND TRADE, 1984-86

	1984		1985		1986P	
	(kilograms)	($000)	(kilograms)	($000)	(kilograms)	($000)
Production[1]						
Platinum, palladium, rhodium, ruthenium, iridium	10 369	..	10 534	..	8 793	..
Exports					(Jan.-Sept.)	
Platinum metals in ores and concentrates						
United Kingdom	8 302	82,012	7 083	51,574	6 378	66,280
United States	163	1,523	92	597	22	504
Total	8 465	83,545	7 175	52,171	6 400	66,783
Platinum metals, refined						
United States	3 724	32,449	4 286	29,423	1 221	14,410
United Kingdom	179	1,834	1 363	8,091	885	5,534
Total	3 906	34,300	5 772	38,480	2 106	19,944
Platinum metals in scrap						
United States	1 831	29,127	1 195	15,880	3 755	8,628
United Kingdom	2 813	21,080	1 854	15,563	490	3,908
West Germany	420	5,478	22	125	-	-
Total	5 064	55,686	3 071	31,568	4 354	13,652
Total	5 064	55,686	3 071	31,568	4 354	13,652
Imports						
Platinum lumps, ingots, powder and sponge						
United States	145	2,117	23	291	316	5,944
United Kingdom	213	3,399	105	1,430	264	4,906
Total	358	5,516	129	1,736	582	10,893
Other platinum group metals						
United States	296	2,197	228	1,058	367	3,284
United Kingdom	46	640	118	1,480	376	2,640
Total	342	2,837	346	2,537	743	5,923
Platinum crucibles[2]						
United States	715	12,778	623	12,674	538	15,583
West Germany	-	-	6	92	0	0
Total	715	12,778	629	12,765	538	15,583
Platinum metals, fabricated materials						
United Kingdom	145	2,396	107	1,472	345	5,844
United States	660	2,969	810	4,102	1 211	10,723
West Germany	22	156	19	212	26	168
Total	827	5,520	936	5,786	1 582	16,734

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Platinum metals, content of concentrates, residues and matte shipped for export. [2] Includes spinners and bushings.

P Preliminary; - Nil; .. Not available.

TABLE 2. PLATINUM SUPPLY AND DEMAND, WESTERN WORLD, 1981-85

	1981	1982	1983	1984	1985
	(000 grams)				
Supply					
South Africa	55 985	60 962	64 383	70 915	72 159
Canada	4 043	3 732	2 488	4 665	4 665
Others	933	933	1 244	1 244	1 244
	60 962	65 627	68 116	76 824	78 069
U.S.S.R. sales	11 508	11 819	9 020	7 776	7 154
Total	72 470	77 447	77 135	84 600	85 222
Demand					
Western Europe	13 063	10 264	10 264	12 752	12 441
Japan	35 768	32 658	29 548	35 457	38 256
North America	21 772	22 083	22 394	28 304	31 414
Rest of western world	4 976	7 154	5 599	5 288	5 288
	75 580	72 159	67 805	80 801	87 399
Western sales to Comecon/China	933	933	933	622	933
Movements in stocks	(4 043)	4 354	8 709	1 866	(3 110)
Total	72 470	77 447	77 135	84 600	85 222

Source: Johnson Matthey Public Limited Company.

TABLE 3. PALLADIUM SUPPLY AND DEMAND, WESTERN WORLD, 1981-85

	1981	1982	1983	1984	1985
	(000 grams)				
Supply					
South Africa	28 304	25 504	24 571	30 481	31 414
Canada	4 976	4 976	3 421	5 910	5 910
Others	2 177	2 177	2 488	2 799	2 799
	35 457	32 658	30 481	39 190	40 123
U.S.S.R. sales	44 477	48 210	48 521	52 875	44 788
Total	79 935	80 868	79 002	92 065	84 911
Demand					
Western Europe	9 331	10 886	14 618	16 174	16 174
Japan	25 504	27 682	37 946	38 779	33 591
North America	25 504	26 749	25 815	30 792	29 237
Rest of western world	4 665	5 288	5 599	6 221	6 221
	65 005	70 604	83 978	92 065	85 222
Movements in stocks	14 929	10 264	(4 976)	-	(311)
Total	79 935	80 868	79 002	92 065	84 911

Source: Johnson Matthey Public Limited Company.
- Nil.

TABLE 4. PLATINUM DEMAND BY APPLICATION, 1981-85

	1981	1982	1983	1984	1985
			(000 grams)		
Western world					
Auto	19 906	20 062	19 129	24 727	27 216
Chemical	7 776	8 087	7 620	8 086	6 998
Electrical	5 754	5 288	5 443	5 910	6 221
Glass	3 110	2 644	3 266	4 354	4 354
Hoarding	-	1 400	2 799	5 288	8 087
Jewellery	23 483	23 794	22 239	24 105	25 194
Petroleum	4 354	2 022	622	467	467
Other	11 197	8 864	6 687	8 864	8 864
Total	75 981	72 160	67 806	81 802	87 401
Japan					
Auto	5 910	5 288	5 288	5 288	5 443
Chemical	311	311	311	467	466
Electrical	467	622	622	933	1 244
Glass	1 555	1 400	1 866	2 333	1 866
Hoarding	-	-	156	467	1 089
Jewellery	19 440	19 284	17 418	19 440	20 995
Petroleum	467	467	467	622	467
Other	7 620	5 288	3 421	5 910	6 687
Total	35 769	32 659	29 548	35 458	38 257
North America					
Auto	13 374	14 152	13 063	18 351	19 595
Chemical	1 555	2 488	3 110	3 110	2 333
Electrical	2 177	2 177	2 799	2 955	2 488
Glass	622	311	467	933	1 244
Hoarding	-	1 244	1 244	933	4 043
Jewellery	467	467	467	467	466
Petroleum	1 711	622	467	467	311
Other	1 866	622	778	1 089	933
Total	21 772	22 083	22 395	28 304	31 415
Rest of western world including Europe					
Auto	622	622	778	1 089	2 177
Chemical	5 910	5 288	4 199	4 510	4 199
Electrical	3 110	2 488	2 022	2 022	2 488
Glass	933	933	933	1 089	1 244
Hoarding	-	156	1 400	3 888	2 955
Jewellery	3 577	4 043	4 354	4 199	3 732
Petroleum	2 177	933	(311)	(622)	(311)
Other	1 711	2 955	2 488	1 866	1 244
Total	18 040	17 418	15 863	18 040	17 729

Source: Johnson Matthey Public Limited Company.
- Nil.

TABLE 5. PALLADIUM DEMAND BY APPLICATION, 1981-85

	1981	1982	1983	1984	1985
			(000 grams)		
Western world					
Auto	8 398	9 020	9 331	9 953	9 020
Dental	14 930	18 351	25 505	27 993	27 060
Electrical	24 883	26 127	33 903	38 257	34 214
Jewellery	6 532	6 843	6 221	6 532	6 532
Other	10 264	10 264	9 020	9 331	8 398
Total	65 006	70 605	83 979	92 066	85 224
Japan					
Auto	4 354	4 977	4 666	4 354	3 110
Dental	4 977	5 910	9 020	9 020	8 398
Electrical	11 197	12 130	20 217	21 150	18 662
Jewellery	1 866	1 866	1 555	1 866	1 866
Other	3 110	2 799	2 488	2 488	1 555
Total	25 505	27 682	37 946	38 879	33 592
North America					
Auto	4 043	4 043	4 666	5 599	5 910
Dental	6 532	8 087	8 709	10 264	10 575
Electrical	10 264	9 953	9 020	11 508	9 331
Jewellery	311	311	311	311	311
Other	4 354	4 354	3 110	3 110	3 110
Total	25 505	26 749	25 816	30 792	29 237
Rest of western world including Europe					
Auto	-	-	-	-	-
Dental	3 421	4 354	7 776	8 709	8 087
Electrical	3 421	4 043	4 666	5 599	6 221
Jewellery	4 354	4 666	4 354	4 354	4 354
Other	2 799	3 110	3 421	3 732	3 732
Total	13 997	16 174	20 217	22 394	22 394

Source: Johnson Matthey Public Limited Company.
- Nil.

TABLE 6. WORLD PRODUCTION OF PLATINUM GROUP METALS, 1981-86

	1981	1982	1983	1984	1985	1986e
			(tonnes)			
U.S.S.R.	104.2	108.9	112.0	115.0	118.2	115.1
Republic of South Africa	96.7	80.9	80.9	108.9	115.1	121.3
Canada	11.9	7.1	7.0	10.4	10.5	8.8
Others	2.8	2.9	3.0	3.6	3.5	3.5
Total	215.6	199.8	202.9	237.9	247.3	248.7

Sources: U.S. Bureau of Mines and Energy, Mines and Resources Canada.
e Estimated.

Potash

G.S. BARRY

SUMMARY

Production of potash in Canada in 1986 was estimated at 6.7 million t (K_2O equivalent), marginally higher than in 1985. Shipments were slightly higher at approximately 7.0 million t compared to 6.6 million t in 1985. Producer's stocks declined to approximately 1.5 million t, which at current levels of monthly shipments is slightly above normal, but could be considered low in times of more buoyant demand. In the United States the deterioration of the agricultural sector continued to weigh negatively on potash demand and Canadian sales to the United States declined by 5 per cent in 1986. There will be a further reduction in grain acreage in the United States, in particular in corn where plantings in 1987 are expected to be below 66 million acres. Consequently demand for potash is likely to decline by 3 to 5 per cent. Prices for potash continued to decline and hit record lows in the third quarter of the year; prices recovered, marginally near year-end. For the second year in a row capacity utilization remained at a very low level of 63 per cent, which in turn results in high unit costs of production. Excess productive capacity principally in Canada will remain a market constraint until the early-1990s, unless more mines in the world close permanently. Consumers show little concern for possible disruption of supply, as a result of mine floodings, and pay more attention to the overhang of unused capacity.

Exports outside North America, referred to as "offshore sales", recorded a large increase of approximately 35 per cent from 1.9 million t in 1985 to 2.6 million t in 1986, which is back to the level already once attained in 1984. There was an improvement in practically all the offshore markets, especially Indonesia, Brazil, Venezuela and Europe. China which withdrew from the potash market for about a year since early-1985 started importing Canadian potash again but still at a level which was less than half of previous imports. Western Europe is rapidly becoming an important market for Canada, accounting for approximately 300 000 t K_2O in 1986 compared to only 15 000 t four years ago. This market is open not only to the new New Brunswick mines but also to Saskatchewan potash sold by Canpotex Limited.

The average value of potash shipped f.o.b. mines was $Cdn 83.08 per t K_2O in 1986 compared to $Cdn 94.51 in 1985 and $Cdn 115.25 in 1984. The average export value calculated by Statistics Canada on the basis of port of exit (e.g. Vancouver) or border crossing to the United States was $Cdn 137.36 per t K_2O in 1986 (based on nine months exports) compared to $Cdn 158.26 in 1985 and $Cdn 169.21 in 1984.

Employment in the Saskatchewan potash industry was estimated at 3,830 in 1986 compared to 3,750 in 1985. In New Brunswick employment in 1986 was 826 practically unchanged from 809 reported for 1985.

For short intermittent periods in the summer and fall, all conventional potash mines in Saskatchewan closed for maintenance, vacation, and on a limited lay-off basis. All the conventional mines except one also schedule closures over the Christmas-New Year period. In 1986 the average closure for the mines, excluding one prolonged mine closure, was approximately 9 weeks, ranging from 4 to 16 weeks.

DOMESTIC DEVELOPMENTS

At the end of 1986, Canadian installed potash production capacity was 9 825 000 t K_2O in Saskatchewan and approximately 750 000 t K_2O in New Brunswick for a total of 10 575 000 t K_2O (17 625 000 t KCl). The largest share of Canadian capacity, 41.4 per cent, is held by Potash Corporation of Saskatchewan (PCS), a provincial Crown corporation, followed by 16.5 per cent for International Minerals & Chemical Corporation (IMC) the largest private producer in the western world.

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The Potash Corporation of Saskatchewan (PCS) recorded a net loss of $69 million in 1985 and Saskatchewan officials estimated the loss may reach $150 million in 1986. The five divisions of Potash Corporation of Saskatchewan Mining Limited produced approximately 3.7 million t of potash (KCl) in 1986, compared to 3 246 000 t in 1985.

PCS's total employment at the end of 1986 was about 1,670 as compared to 1,756 in 1985. The company's mines were closed during the first week of 1986, and from June 29 to July 25, 1986. All the mines were also closed for the 1986 Christmas period. The Lanigan mine was closed by a strike from March 10, 1986 to the end of the year. Expansion of this mine was almost completed during 1986. The company continued to operate all but one of its mines on a 10-day per fortnight schedule, thus reducing one shift per week from the traditional four shifts per week schedule.

PCS Mining operated a 30 000 tpy potassium sulphate plant at the Cory mine. In late-1986 capacity utilization was approximately 50 per cent. The plant follows the same 10 days per fortnight schedule adopted for the potash mine. The company also started construction of a small 10 tpd industrial grade potassium sulphate plant at Big Quill Lakes. The company completed a feasibility study on a large, 300 000 tpy plant (fertilizer grade) but a decision on its construction has not yet been made.

Central Canada Potash, a subsidiary of Noranda Inc., produced about 800 000 t of potash (KCl) in 1986 compared to 1.0 million t in 1985. The company closed its Colonsay mine from December 21, 1985 to February 19, 1986, and from July 15 to September 4, 1986. As of December 15, 1986 the mine was closed again and is expected to resume production in mid-February 1987. The operational schedule is seven days per week while in production.

Cominco Ltd. produced 896 000 t (KCl) in 1986 compared to 1 034 000 t in 1985. The company closed its Vanscoy mine from December 20, 1985 to January 5, 1986, from June 30 to September 15, 1986 and again from December 14, 1986 for an indefinite period of one to two months. While in operation the mine is run on a seven day per week basis to reduce unit costs.

The International Minerals & Chemical Corporation (IMC) reports Saskatchewan potash reserves in its Annual Report ending June 30, 1986 at 1 331 million t averaging 25 per cent K_2O. The company mined 7 million t in fiscal year 1986 and produced about 2.8 million t of product, of which slightly more than 20 per cent was on PCS account. The average realised price for potash was $US 43 per s.t. in 1985-86 compared to $US 53 per s.t. in 1984-85. The company also reported that productivity per man-shift in the Canadian potash operations improved by 22 per cent between mid-1980 and mid-1986.

IMC operated two mines near Esterhazy. The K1 mine was closed between December 22, 1985 and January 7, 1986 and between June 21 and July 7, 1986. It also closed for the holidays between December 24, 1986 and January 7, 1987.

The K2 mine experienced a serious water inflow starting in December 1985 and gradually resumed operation in March 1986. The K2 mine was partially flooded. Pumping water to the surface for disposal into deep wells started in January 1986. A temporary increase in the water inflow, which at its peak may have exceeded 10 000 gal. per minute, required the installation of additional pumping facilities during a second closure of K2 between June 9 and July 7, 1986. Drilling from surface and conventional grouting with chemically treated cement took place during the second part of the year. Starting in October, the company experimented with a new form of grouting, with a saturated solution of calcium chloride which in turn precipitates sodium chloride acting as a grout. The inflow of water decreased substantially but in the last few days of December water inflows in the affected areas increased again. Efforts to grout and backfill the affected area with waste salt to reduce subsidence will continue in 1987.

Kalium Chemicals, a division of PPG Canada Inc. almost completed its expansion work at the Belle Plaine mine 80 km west of Regina. Because of market conditions the actual completion will be stretched out until mid-1987. In mid-year Kalium closed one line (half of capacity) between mid-June and mid-August and the second line between mid-July and mid-August. For the first half of 1987 the company plans to operate at about 80 per cent of capacity due to market conditions. Employment is about 240.

Potash Company of America, Inc. in which Rio Algom Limited holds an 87.8 per cent interest, closed its Patience Lake mine from July 12 to August 5, 1986. The company experienced water inflows since

February. Initially applied conventional grouting techniques did not give positive results and the company decided to seal off part of the mine by building 14 bulkheads (cement plugs about 33 m wide). The program will cost up to $20 million and should be completed within the next six months. The first bulkhead will be poured in the second week of January 1987. During the Christmas period water inflow increased substantially and the time element to save the mine is critical. While this work is in progress the mine will be operated at 70 per cent capacity or less.

Canada Development Corporation (CDC) has agreed to sell its wholly-owned Saskterra Fertilizers Ltd. subsidiary to Canterra Energy Ltd. of Calgary for $35.9 million. The ownership transfer is effective December 1, 1986. Saskterra owns 40 per cent of the Allan potash mine, one of the assets that CDC retained when it sold Kidd Creek Mines Ltd. to Falconbridge Limited. Saskterra will continue to use Texasgulf Inc. as a sales agent for potash destined to the U.S. market. The company will also retain its membership in Canpotex for its offshore sales.

MANITOBA

Canamax Resources Inc. and the Manitoba government agreed in May 1986 to form Manitoba Potash Corporation in which Canamax will hold a 51 per cent interest and the Manitoba government 49 per cent.

Manitoba provided $6 million to complete the feasibility for bringing a potash mine into production. During 1986 additional seismic work was carried out and a 900 m shaft pilot hole was completed between July 25 and September 28, 1986. Kilborn Engineering Limited is scheduled to complete an engineering feasibility study by mid-1987. The Manitoba government held talks with major consumers in Asia, offering equity participation in the proposed mine. Towards the end of 1986 it was reported that interest was expressed by the Minerals & Metals Trading Corp. of India Ltd. (MMTC).

NEW BRUNSWICK

The Potash Company of America (PCA), majority owned by Rio Algom Limited operates the Penobsquis mine situated 5 km east of Sussex, N.B. The company committed an additional $30 million to upgrade the mine and achieve the designed capacity of 380 000 tpy K_2O by early-1988. Satisfactory progress was made during 1986. The shaft and some surface installation were designed to a capacity of 545 000 tpy K_2O.

The Denison-Potacan Potash Company operated its new Cloverhill mine located 20 km southwest of Sussex, N.B. at about half the designed capacity level of 790 000 tpy. Production for 1986 was 392 000 t K_2O compared to 83 000 t K_2O in 1985. The company is expected to achieve full operational capacity by the end of 1987 or early-1988. Because of the complexity of the orebody the company intends to continue extracting ore both by drill and blast methods and with continuous mining machines. In early-1987 the company intends to return waste salt to the mine as backfill. Waste salt is currently stored on the surface on a temporary basis in an 80 acre tailings pond lined with a high density polyethylene liner. Excess brine is dispatched by pipeline to the Bay of Fundy.

BP Resources Canada Limited (Selco Division) is holding the third commercially viable potash deposit near Sussex, N.B., known as the Millstream deposit. BP obtained a mining lease in 1985. Because of the generally depressed potash market conditions the company deferred a decision, to 1987, on whether to proceed with an exploration shaft.

INTERNATIONAL DEVELOPMENT

World production in 1986 is estimated at 27.4 million t K_2O, a 4.0 per cent decline from 1985. Production in the U.S.S.R. had to be revised downward, because of the complete loss to flooding of one mine which accounts for most of the decline.

Argentina - Yacimientos Petroliferos Fiscales (YPF) discovered a potash deposit while drilling for oil in the Province of Mendoza, Department of Malargue along Rio Colorado. The potash occurs in the Huitrin saline formation, which lies at various depths between 750 and 1 200 m. The deposits are explored under concession by Duval Corporation and Minera TEA, a subsidiary of Texasgulf Inc. Originally it was reported that the potash beds were 1 to 4 m thick consisting of sylvinite ore grading up to 27 per cent K_2O. In August 1986 it was reported that the indications are for 2 billion t of ore grading 20 to 30 per cent KCl (12 to 18 per cent K_2O) in beds 2 to 10 m thick.

Brazil - PETROBRAS Mineracão S.A. (PETROMISA) officially opened the Taquari-Vassouras potash mine in the Sergipe district in March 1985. However as of the end of 1986, all the mining equipment was not yet in place and only very limited commercial sales of less than 50 000 t were made.

PETROMISA holds another interesting potash deposit near Fazendinha in the Amazonian basin. The deposit has an area extent of 130 km^2, an average thickness of 2.7 m and lies at a depth of 980 m to 1 140 m. Total reserves are estimated at 560 million t grading about 27 per cent KCl. In 1984, a $700,000 feasibility contract was awarded to a joint venture consisting of Paulo Abib Engenharia, Mines de Potasse d'Alsace and Patrick Harrison & Company Limited, a Canadian firm. Phase I of this study outlining development options was completed in September 1985 and Phase II comprising a more detailed engineering feasibility was started in 1986. For the first 9 months of 1986 Brazil imported 1.4 million t KCl, 27 per cent came from Canada and 26 per cent from the German Democratic Republic.

Chile - AMAX Chemical Corporation jointly with Molibdenos y Metales SA (Molymet) were awarded the rights by Corporacion de Fomento de la Produccion to develop the potash-lithium-boric acid deposits of the Salar de Atacama. The target size of the project is 500 000 tpy KCl, 200 000 tpy K_2SO_4, 30 000 tpy of boric acid and an undetermined amount of lithium chemicals, the last depending on demand. Following successful field testing and a feasibility study, production could become a reality by the mid-1990s.

China - A small potash plant, serving local markets, exists at the eastern part of a dry lake, Lake Qarhan (Chaerhan) in the Qinghai province. Output is about 40 000 tpy (KCl) of low-grade product grading between 45 and 50 per cent K_2O. Brines are pumped into solar ponds from trenches dug into the dry salt lake surface. Concentrated salts from the solar ponds are subject to rough flotation producing the low-grade product. Currently, construction began on additional solar ponds that will eventually provide the raw material for a nearby plant of 200 000 tpy (KCl) capacity to be completed by 1989 or 1990. This plant will in fact be a five-times scale up model of the existing plant, based on Chinese technology; capital costs are estimated at 270 million yuan ($US 75 million).

A western harvesting machine for the solar potash pond will be ordered. The Chinese are also interested in contracting a feasibility study on a 800 000 tpy (KCl) plant for the west end of Lake Qarhan (Chaerhan) to be based on western technology that would yield a high-grade product for markets outside western China. Such a plant would require $500 to $600 million in investment and is not likely to be completed earlier than in mid- to late-1990s.

Chinese annual consumption of potash is variously estimated at between 600 000 t and 800 000 t K_2O. Imports declined to very low levels in 1985. There was an improvement in 1986 and a better market is expected in 1987. By 1990 consumption may reach 900 000 t to 1.0 million t.

Congo (People's Republic) - Entreprise minière et chimique (EMS) signed a joint venture agreement with the Congo government to establish the feasibility of mining potash again at Holle, near Pointe Noire. Mining was carried out there from 1969 to 1977 when the mine was flooded.

Ethiopia - A two-year feasibility study on potash production in the Danakil Depression by Entreprise minière et chimique for the Ethiopian-Libyan Mining Co., was in progress in 1985 and 1986. The region produced some carnallite before the Second World War. In 1965 and 1966 a shaft was sunk at Musley into sylvinite beds by the Ralph M. Parsons Company of the United States but the 500 000 tpy project was abandoned in 1968.

France - Production in 1986 was approximately 100 000 t K_2O less than in 1985, principally in response to lower domestic consumption, higher imports and the closure of the Theodore mine in March 1986. Mines de Potasse d'Alsace put into operation a new flotation plant at the Amelie mine, increasing recovery and thus partially compensating for the Theodore closure. A second mine will be closed in four to five years resulting in a further decrease of French capacity by up to 400 000 tpy. In October 1986 the French Ministry of Environment announced a F Fr 350 million program to appreciably reduce the discharge of waste salt into the Rhine. Under the plan, a total reduction of 60 kg per second (1.9 million tpy) would be implemented over a two-year period. The first phase, equivalent to a reduction of 20 kg per second will be implemented on January 5, 1987. Eventually all of the waste salt will be stocked on the surface and only a small portion will be used for road de-icing. Some excess brines will be pumped into deep wells. The injection of the waste salt into deep wells, proposed as a solution over the last few years, has been abandoned.

German Democratic Republic (GDR) - Production from ten mines in the GDR for the past few years has been more or less steady. In 1985 GDR produced 3 465 000 t K_2O and in 1986 production is estimated at 3 485 000 t K_2O. GDR, through its marketing agency Kali-Bergbau currently exports approximately 2.85 million t K_2O of which about 56 per cent is to market economies and China, and 44 per cent to COMECON countries which includes Cuba. GDR completed major increases in compaction facilities and currently about 24 per cent of potash destined for export is in the granular form. The Dorndorf mine started production of potassium sulphate at a rate of approximately 100 000 tpy.

Germany, Federal Republic of (FRG) - Kali und Salz AG (K&S) is the sole producer of potash in FRG. Production in 1986 was estimated at 2.2 million t, a significant decline from 1985. FGR is the major exporter of potash in western Europe. In response to weak demand and in order to avoid an increase in inventories, all the mines were closed for the Christmas period of 1985 and until mid-January 1986. Subsequently the mines were operated at about 80 per cent of capacity for the first half of 1986 and closed for an additional two weeks in the second half of the year. In total K&S mine closures were equivalent to 11 to 13 weeks including holidays, in 1986.

India - India has no domestic production of potash and imports it mainly from Canada, GDR, Jordan and FRG. About 1/3 of its 800 000 to 900 000 t K_2O annual import requirements come from Canada. Recently the government-owned Minerals & Metals Trading Corp. of India Ltd. (MMTC) expressed some interest in acquiring equity in a Canadian potash mine. In particular MMTC is examining the proposal to take a 20 to 25 per cent equity in a proposed new mine in Manitoba.

Israel - The Dead Sea Works Ltd. potash plant at Sdom has a capacity of 2.1 million tpy KCl. An additional 200 000 tpy capacity will be added over the next two to three years. The current expansion work involves the debottlenecking of the hot crystallization plant, modifications to the cold crystallization plant and modifications to the solar ponds by switching a salt pond to carnallite precipitation. Further capacity additions are possible in the future if new ponds are added. Major improvements to the transportation system, including an 18 km conveyor belt from Sdom to the rail terminal at Tzefa which will eliminate costly truck haulage, are almost completed. Dead Sea Works Ltd. withdrew from Kali-Export (KEG), the Vienna based export association, in May 1986. Haifa Chemicals Ltd. expanded its potassium nitrate capacity from 200 000 tpy to 250 000 tpy KNO_3.

Italy - Societa Italiana Sali Alcalini SpA (Italkali), a government controlled company, produces potassium sulphates from two Sicilian mine groups. Realmonte produces about 400 000 tpy of kainite ore and Pasquasia about 1.5 million tpy. Two refineries at Casteltermini and Pasquasia produce up to 275 000 tpy of potassium sulphate. Casteltermini also produces up to 15 000 t of potassium magnesium sulphate. Italkali plans to increase its production capacity to 500 000 tpy of potassium sulphate by 1990.

Jordan - The Arab Potash Co. Ltd. (APC) made steady progress toward full capacity utilization of its Dead Sea potash plant at Ghor-al-Safi. Production in 1986 was estimated at over 1.0 million t KCl compared to 908 560 t produced in 1985. Output should increase in 1987 to about 1.1 million t but full capacity will not be reached until modifications are made to the plant as well as to the solar ponds system. APC intends to spend about $US 26 million on the project of which about $US 12 million would come from the World Bank. APC will also be given a grant of $US 1.5 million from the U.S. Agency for International Development to experiment with a cold leach and crystallization process which could save energy.

Mexico - Fertilizantes de Mexico SA has once again put its Cerro Prieto potash project on hold after apparently completing some construction on solar ponds. Priorities have changed and there is doubt that the company will re-activate the project over the next few years. The projected capacity was 80 000 tpy KCl. Apparently the geothermal brines presently utilized for energy do not contain that much potash.

Spain - Potassas de Navarra SA, a subsidiary of Instituto Nacional de Industria (INI), ceased mining at the Pamplona mine as of December 31, 1985. The company however continued to mill potash ore from Pamplona for about 3 or 4 months of 1986 until potash ore from the new Subiza deposit became available. It was reported that Subiza's output will be in the order of 150 000 tpy. The new operating company is Potasas de Subiza owned 50 per cent by INI and 50 per cent by the local government, El Gobierno Foral de Navarra. Ore reserves are limited but will allow for the operation of Subiza to the 1993-95 period. Thereafter, potash mining in Spain will be concentrated in the Catalonia district where capacity at the Suria mine will be expanded. There is also a possibility of opening a new mine between Suria and Llobregat in the more distant future. There is some uncertainty of whether the Cordona mine can remain in operation in the 1990s, unless major exploration efforts are successful.

Tunisia - An initial feasibility study was completed on the possibilities of extracting potassium and other salts from the Zarzis brines by French companies. Societé de Développement des Industries Chimiques du Sud (S.D.I.C.S.) is reported to be looking for companies interested in pursuing further research and development. Apparently a 120 000 tpy K_2O potassium sulphate plant would be a part of the development plan.

Thailand - Thailand has two potash bearing saline basins, the Khorat and the Sakhon-Nakhon basins. The department of Mineral Resources (DMR) started a pilot project in 1982 to demonstrate the feasibility of carnallite exploitation near Chaiyaphum in the Khorat Basin. An inclined access drift was sunk but had to be abandoned because of high water inflow in 1983. In December 1985 DMR announced that it reviewed the mining project with the possibility of going ahead, but it is now apparent that the rehabilitation of this mine is not feasible.

In 1984 two potash concessions were awarded: one to Thai Potash Co. Ltd. (CRA Limited - Duval Corporation - Siam Cement of Thailand) on 3 500 km^2 and the other to Thai Agrico Potash Co. Ltd. (Agrico Chemical Co. - Thai Central Chemical) on 2 333 km^2. Each company is committed to spend on exploration a total of $US 3 million over a five-year period. It was reported recently that Agrico is looking to reduce its stake in the venture to 25 per cent. During 1986 DMR received indications of interest from the Chinese on a third concession in the northern part of the basin. The Thai deposits present a geological challenge since the disposition of secondary sylvinitic ore is discontinuous in predominantly carnallitic potash formations.

United Kingdom - Cleveland Potash Ltd. had an exceptionally good year and produced approximately 390 000 t K_2O in 1986. The company completed the installation of a pilot facility to recover potash from brines. The unit is working exceptionally well and much above originally designed capacity; it is based on a refrigeration technique whereby potash crystals are separated from the frozen brine. The company pioneered many new mining techniques to mine in very difficult ground conditions. In October it completed the world's longest horizontal exploration hole of 2 079 m.

United States - Production in 1986 was estimated at just below 1 200 000 t K_2O, marginally above 1985 level. The industry experienced a very low first quarter when two out of five New Mexico mines were shut. There was a slight improvement in the second half of the year when mines operated at an annualized rate of 1 375 000 t. Production in 1987 is expected to show little change and will continue to decline thereafter as more U.S. potash capacity is closed. There is a possibility, however, that a new solution mine in Michigan could start in the 1992-95 period and this is reflected in the world capacity table.

Great Salt Lake Minerals & Chemicals Corp. (G.S.L.) indicated that its facility in Utah is not likely to resume production before 1989 as a result of an all time record high level of the Great Salt Lake. G.S.L. ponds and dykes are in good condition and there is brine in the collection system. An added permanent problem is the lower salts content in lake brines as a result of the breaching of the causeway. Kaiser Aluminum & Chemical Corporation, the other potash producer from brines in Utah, reported a normal year of operation. The company relies on brines from a desert salt flat.

AMAX Chemical Corporation reopened its Carlsbad, N.M. mine on March 30, 1986. The mine was closed since October 5, 1985. The company is now concentrating on mining the remaining reserves in the higher grade No. 3 zone and is effectively operating at a capacity of approximately 360 000 tpy K_2O. Reserves are not expected to last for more than two to three years.

New Mexico Potash Corp. now operates the former Kerr-McGee mine at Hobbs, N.M. at about half the rate of the former capacity of 300 000 tpy, mainly producing chemical grades of potash.

Lundberg Industries Inc. reopened the former PCA mine at Carlsbad, N.M. in March 1986 and operated it successfully for the remainder of the year at a capacity level of approximately 380 000 tpy K_2O. Ore reserves are limited to a few years.

PPG Canada Inc. completed the construction of test facilities at their Hersey site in Michigan in August 1985 under a $5 million program which will test the feasibility of solution mining of potash beds that occur at a depth of 7,500 to 8,000 feet in the Michigan salt basin. Technical tests were carried out during 1986, and the plant was closed. Favourable results could lead to construction of a 425 000 tpy K_2O plant by the early-1990s at a cost of about $250 million. However to date, no decision on whether to proceed with a full feasibility study has been made.

During the second half of the year some U.S. companies and officials from the state of New Mexico, the town of Carlsbad and the unions announced their displeasure at what was perceived by them as dumping of Canadian potash. These allegations were very tenuous and as of the end of 1986 there was still no clear indication that the complainants will file an anti-dumping petition with the International Trade Commission, although the press reported that they are continuing to gather data for such action. Towards the end of January 1987, U.S. sources indicated that an anti-dumping petition is likely.

U.S.S.R. - The U.S.S.R. is the world's leading producer of potash and the second largest exporter after Canada. In 1985 the U.S.S.R. exported 3 247 100 t of which 28 per cent was to market economies and China and 72 per cent to COMECON countries, including Cuba, North Korea and Vietnam. Exports in 1986 were lower due to production deficiencies. The Berezniki 3 mine in the Urals, one of the most modern mines in the U.S.S.R., was flooded in March 1986. This mine had a capacity of 1 150 000 tpy K_2O (lower than the 1 450 000 t K_2O level reported in the press). The loss of this mine will probably be permanent.

Towards the end of 1985, reports were circulated that the Berezniki 4 mine, currently under construction, also experienced partial or complete flooding. However in late-January 1987 officials from the ministry responsible for fertilisers denied that the Berezniki 4 mine was flooded. The loss of the Berezniki 4 mine would have been vital to the world supply-demand situation after 1988. Contrary to press reports this mine was never in commercial operation (at a reported initial capacity of 750 000 t K_2O in 1985). The first phase of this mine was scheduled to become operational in late-1987 or early-1988. However Berezniki 4 was designed to be the largest of the Soviet potash mines, reaching a capacity of 1.6 million t K_2O by 1995.

The total capacity of the Soviet Union was revised downward to 10 075 000 t K_2O in 1986 to account for the partial loss of Berezniki 3 and to 9 905 000 t K_2O in 1987 to account for the total loss of this mine. Beginning in 1987 the capacity will rise again. However, Table 11 does not contain an adjustment for Berezniki 4 since the press and industry reported flooding event there, has been subsequently denied. The Novosolikamsk mine currently operates at a capacity of between 600 000 t and 700 000 t and is still under expansion to approximately 1.2 million t K_2O in the early-1990s. Research facilities at the Karlyuk potash brines operation are already in place and small quantities of potash were produced. It is surmised that a larger plant will not be completed and effectively operational at 100 000 t K_2O before 1990-91. The Soviet Union chose to continue exports at normal levels for most of 1986. It is only towards the end of the year that a decline took place, particularly through the Pacific port of Nakhodka. It is probable that a noticeable drop in exports will occur in 1987 and that COMECON countries as well as exports to the west will share in the deficiency.

RESEARCH AND DEVELOPMENT

The Canada Centre for Mineral and Energy Technology (CANMET) with the close cooperation of the potash industry is involved in a number of R&D potash projects. CANMET involvement began in 1983 under the START program (Short Term Aid to industry for Research and Technology).

Projects completed under START are as follows:

- Environmental changes associated with potash tailings stored on surface.
- Guide to government regulations for potash mining and processing concerning the environment.
- Alternatives to present potash mining in Canada.
- Assessment of possible problems in regional mine stability with future mining of Saskatchewan potash.

- Creep cell evaluation and laboratory testing of large evaporite samples.

- Numerical modelling package to design underground openings in potash.

- Determination of engineering properties of waste salt for backfilling underground potash mines.

- Dust measuring techniques and dust levels in potash mines.

- Absolute convergence measurements in potash mine openings.

- A field test program to evaluate the use of waste salt backfill in Saskatchewan potash mines.

Federal-provincial-industry potash R&D is also being conducted under the current five-year Mineral Development Agreements (MDA) with the provinces of New Brunswick and Saskatchewan. The following studies were completed or are in progress:

- Electrostatic separation of potash ore.

- Dense medium Tri-flow separation of potash ore.

- High intensity, high gradient magnetic separation of insolubles in clays from potash salts.

- Use of backfill in New Brunswick potash mines.

In addition the following are either planned or in the initial stages of implementation:

- Regional subsidence related to potash mining.

- Research on microseismic technology.

- Offshore product quality.

- Surface tailings and brine containment.

CANMET is also developing a computer controlled model "on numerical modelling of excavations in potash". It is based on laboratory testing and field monitoring. Specifically the projects are:

- Identification of input parameters for numerical modelling of potash strata at IMC, Sask.

- Laboratory testing and field monitoring for numerical modelling of excavations in potash (Cominco Ltd., Sask.).

For further information on potash R&D contacts at CANMET (tel. 613-995-4029) are: R.K. Collings, K.S. Moon and Dr. G. Herget.

PRICES

Typical contract prices for Canadian potash (standard grade KCl) moving out of Vancouver were $US 74 to $78/t (f.o.b. vessel), the beginning of the year.

Prices decline slightly and held at the $US 70 to $72/t level between February and July. There was a rapid decline to just below $US 60/t between August and December. A slight improvement occurred at the end of the year.

Prices for delivery in the United States were $US 38/s.t. f.o.b. mine at the beginning of the year, $US 41/s.t. in April; $US 38/s.t. at and past mid-year; $US 44/s.t. towards the end of the third quarter and were listed at about $US 52/s.t. by year-end. Some companies instituted a "winter fill" program in 1985/86 and again in 1986/87. This allowance ranged from $US 2 to $8/s.t. depending on the month in which potash was due to be delivered.

OUTLOOK

After a very disappointing 1986, prospects for 1987 are not much better. Prices bottomed out in the third quarter of 1986 and could be higher in 1987, but most mines will operate at much less than optimum capacity levels. Temporary closures will continue to be necessary.

Agronomists expect that grain planting acreage reductions in the United States will result in a further decline of potash utilization of up to 5 per cent next year. Canadian sales to the United States potash market could remain at the same low level of 4.1 million t K_2O if U.S. domestic production declines and offshore competitors export slightly less to the U.S. market. If these conditions are not met, a decline to about 3.9 million t K_2O is at the low range of expectations.

Canadian capacity utilization in 1987 will increase marginally to just above the 65 per cent level, but capacity utilization of 80 per cent, which is still below optimum, will not be reached before 1990.

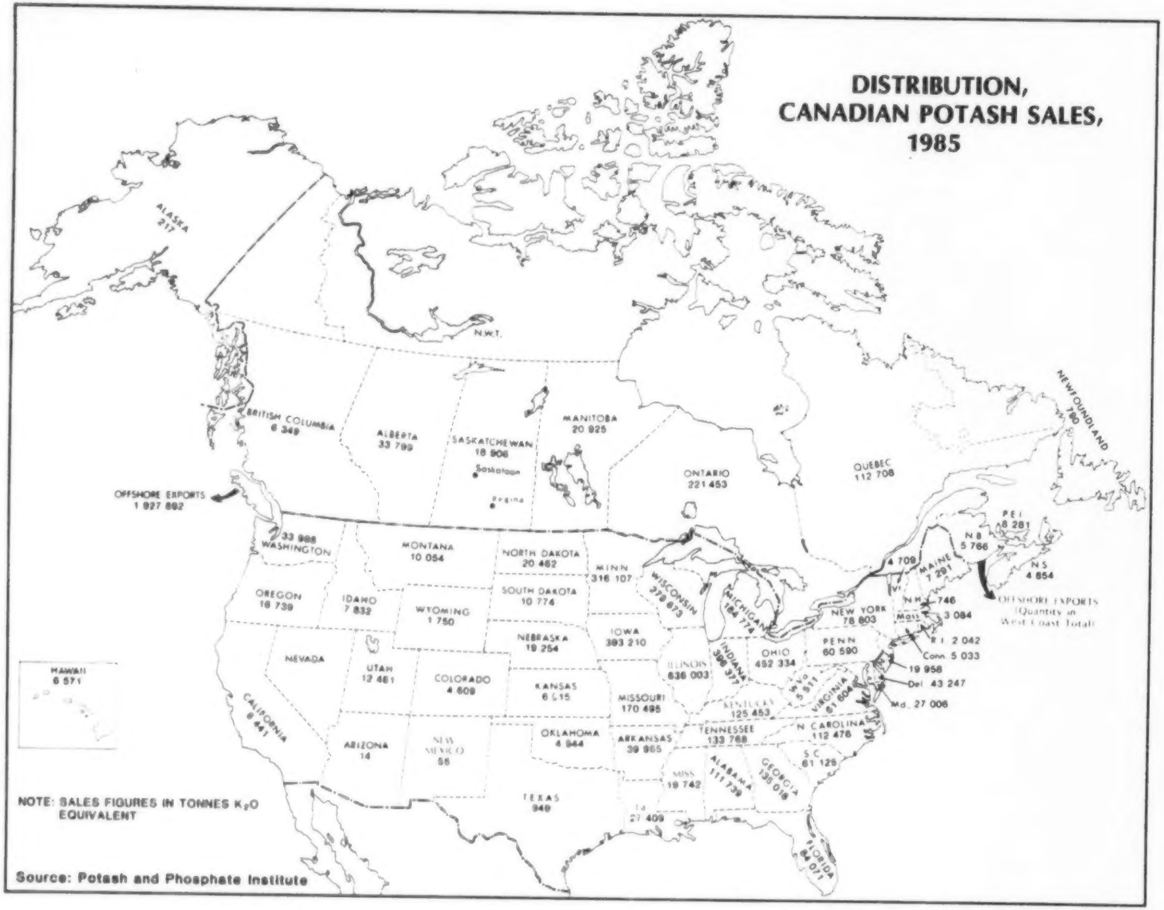
The U.S.S.R. is likely to decrease potash exports to the western economies and COMECON countries, but the main burden of restricted supply on account of its mine floodings will fall on its own domestic consumption prospects. However after 1987, domestic needs are bound to take precedence over high export levels so exports are expected to continue to decline for the indefinite future.

It is reasonable to expect a further improvement in demand from most Latin American as well as Asian countries, particularly China, so that Canadian offshore exports in 1987 should reach a record level.

The difficulties experienced by Canadian mines are also bound to have a sobering effect on consumers that have grown complacent on account of the large overhang of unused capacity.

However, it will take four to six years, depending on the rapidly changing circumstances, before new additions to capacity are required anywhere in the world, in particular since already ongoing, committed expansions will add 1.5 million t by 1990. It is assumed that world demand for potash will resume an upward growth of about 2.0 per cent per year or slightly more.

DISTRIBUTION, CANADIAN POTASH SALES, 1985


ALASKA 217
N.W.T.
NEWFOUNDLAND 780
BRITISH COLUMBIA 6 349
ALBERTA 33 799
SASKATCHEWAN 18 906
Saskatoon
Regina
MANITOBA 20 925
ONTARIO 221 453
QUEBEC 112 708
P E I 8 281
N B 5 766
N S 4 854
OFFSHORE EXPORTS 1 927 892
OFFSHORE EXPORTS (Quantity in West Coast Total)
33 988 WASHINGTON
OREGON 16 739
IDAHO 7 832
MONTANA 10 054
WYOMING 1 750
NEVADA
UTAH 12 461
COLORADO 4 609
CALIFORNIA 6 441
ARIZONA 14
NEW MEXICO 55
NORTH DAKOTA 20 462
SOUTH DAKOTA 10 774
NEBRASKA 19 254
KANSAS 6 515
OKLAHOMA 4 944
TEXAS 949
MINN 316 107
IOWA 393 210
MISSOURI 170 495
ARKANSAS 39 865
La 27 409
WISCONSIN 279 673
ILLINOIS 636 003
MISS 19 742
MICHIGAN 184 774
INDIANA 396 377
KENTUCKY 125 453
TENNESSEE 133 768
ALABAMA 111 739
OHIO 452 334
W Va 5 511
VIRGINIA 61 604
N CAROLINA 112 476
S C 61 125
GEORGIA 135 016
FLORIDA 84 071
PENN 60 590
NEW YORK 76 803
Vt 4 709
MAINE 7 291
N H 746
Mass 3 084
R I 2 042
Conn 5 033
19 958
Del 43 247
Md 27 006
HAWAII 6 571

NOTE: SALES FIGURES IN TONNES K_2O EQUIVALENT

Source: Potash and Phosphate Institute

TABLE 1. CANADA, POTASH PRODUCTION, SHIPMENTS AND TRADE, 1984-86

	1984		1985		1986P	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Production, potassium chloride						
Gross weight	12 768 000	..	10 959 990	..	..	..
K_2O equivalent	7 794 000	..	6 694 507	..	..	..
Shipments						
K_2O equivalent	7 527 000	867,540	6 661 077	629,547	6 968 676	579,022
Imports, fertilizer potash						
Potassium chloride						
United States	1 768	889	707	622	390	458
United Kingdom	4	1	–	–	–	–
Total	1 772	890	707	622	390	458
Potassium sulphate						
United States	10 138	2,377	27 654	2,831	25 668	4,822
France	–	–	3 001	846	–	–
Italy	–	–	182	48	338	94
Total	10 138	2,377	30 837	3,725	26 006	4,917
Potassic fertilizer, nes						
United States	68 185	6,796	33 687	4,794	23 968	3,935
Potash chemicals						
Potassium carbonate	1 757	1,063	1 170	738	1 360	1,164
Potassium hydroxide	2 936	2,089	2 620	1,777	4 387	2,240
Potassium nitrate	3 386	1,754	4 505	2,237	4 035	2,097
Potassium phosphate	1 954	2,644	2 074	2,456	3 732	3,885
Potassium silicates	684	561	4 744	3,945	697	585
Total potassium chemicals	10 717	8,111	15 113	11,153	10 774	7,676
Exports, fertilizer potash						
Potassium chloride, muriate[1]						
United States	7 307 192r	679,318r	6 449 767	525,651	5 876 520	425,520
Brazil	487 068	60,232	425 011	53,123	776 599	79,797
Japan	684 981	83,623	625 882	79,828	564 438	56,220
India	636 352	77,963	528 403	67,291	469 229	47,254
South Korea	399 322	49,042	331 681	42,252	394 632	39,335
People's Republic of China	577 146	71,156	194 351	24,285	310 845	27,226
Indonesia	94 151	11,277	179 050	23,009	224 387	23,489
Malaysia	101 784	12,730	153 160	18,465	193 458	19,615
Australia	234 633	28,630	166 130	21,485	176 839	17,644
France	180 650	17,353	102 236	12,577	149 337	14,895
Venezuela	14 733	1,356	–	–	70 006	7,333
Denmark	30 089	2,469	27 728	2,594	85 943	8,083
Belgium	–	–	–	–	77 099	7,838
Chile	44 022	5,378	36 251	4,455	53 956	5,465
Mexico	30 000	3,597	63 025	6,673	49 209	5,078
Taiwan	80 851	9,723	64 767	8,472	42 151	4,424
Italy	–	–	29 213	3,126	41 269	4,045
Hong Kong	–	–	–	–	34 945	3,614
United Kingdom	29 530	3,817	33 212	4,004	31 364	3,350
New Zealand	51 183	6,323	20 089	2,590	36 537	3,735
Netherlands	–	–	–	–	41 660	4,155
Guatemala	–	–	–	–	27 843	2,906
South Africa	55 582	6,834	41 501	5,414	24 634	2,504
Philippines	36 993	4,543	21 642	2,811	18 000	1,872
Singapore	226 679	27,827	136 401	17,828	17 893	1,863
Ireland	39 823	4,861	17 229	2,270	14 108	1,648
Bangladesh	77 153	9,376	94 846	10,778	15 750	1,736
Other countries	73 821	8,997	60 885	7,368	75 431	7,500
Total	11 493 732r	1,186,425r	9 802 460	946,349	9 894 082	828,144

Sources: Statistics Canada; Energy, Mines and Resources, Canada.
P Preliminary; – Nil; .. Not available; nes Not elsewhere specified; r Revised.

[1] Special Note: Exports for 1986 shown in the above columns are the latest Statistics Canada data, corrected in early-1987. Users should be aware that Statistics Canada's monthly published export statistics for November and December 1986 are in error, including the cumulative 1986 data (reference to "Exports by Commodities" - cat. 65-004, Class 416-52). Statistics Canada will publish revised data in its subsequent publication in the form of "errata" sheets.

TABLE 2. CANADA, POTASH PRODUCTION AND SALES BY GRADE[1] AND DESTINATION, 1984 AND 1985

	1985						1984
	Standard[2]	Coarse	Granular	Soluble	Chemical[3]	Total	Total
	(tonnes K_2O equivalent)						
Production	1 709 204	2 081 726	2 117 255	664 807	63 665	6 636 658	7 748 696
Sales							
Canada	34 080	183 365	198 713	17 672	..	433 830	435 837
United States	330 177	1 951 846	1 386 263	492 328	..	4 160 614	4 087 853
Offshore							
Australia	8 310	18 977	68 367	-	..	95 654	142 996
Bangladesh	28 802	-	-	-	..	28 802	42 546
Brazil	64 531	12 890	175 733	-	..	253 154	268 509
Chile	24 232	-	-	-	..	24 232	20 105
China	105 682	-	-	-	..	105 682	419 555
Costa Rica	10 550	1 287	999	-	..	12 836	12 498
Denmark	20 065	-	-	-	..	20 065	9 165
Dom. Rep.	-	-	2 683	-	..	2 683	-
France	46 881	-	-	-	..	46 881	109 350
Ghana	-	-	-	-	..	-	11
Guatemala	2 480	-	610	-	..	3 090	-
Honduras	(34 773)	-	-	-	..	(34 733)	-
India	303 069	-	-	9 072	..	312 141	405 887
Indonesia	104 668	-	-	-	..	104 668	74 286
Ireland	-	-	6 851	-	..	6 851	41 572
Italy	-	-	-	18 364	..	18 364	-
Jamaica	-	3 464	-	-	..	3 464	6 985
Japan	104 440	65 649	34 786	154 780	..	359 654	383 298
Korea, South	180 816	-	-	5 533	..	186 349	240 409
Malaysia	127 505	-	-	-	..	127 505	128 639
Martinique	-	-	872	-	..	872	-
Mexico	25 491	-	12 711	31	..	38 233	18 247
New Zealand	21 360	3 069	-	-	..	24 429	46 364
Nicaragua	-	-	-	-	..	-	9 555
Panama	-	-	885	-	..	885	-
Peru	1 281	-	-	-	..	1 281	-
Philippines	22 415	-	-	-	..	22 415	25 598
Romania	-	-	-	-	..	-	32
South Africa	13 986	-	11 242	-	..	25 228	27 714
Sri Lanka	43 732	-	-	-	..	43 732	42 173
Switzerland	31 260	-	19 169	-	..	50 429	-
Taiwan	39 367	-	-	-	..	39 367	68 340
United Kingdom	455	-	-	-	..	455	616
Venezuela	-	-	3 222	-	..	3 222	-
Offshore total	1 296 646	105 336	338 131	187 780	..	1 927 892	2 544 450
Total sales	1 660 903	2 240 547	1 923 107	697 780		6 522 337	7 068 140

Source: Potash and Phosphate Institute.

[1] Common specifications are: standard -28 to +65 mesh, special standard -35 to +200 mesh, coarse -8 to +28 mesh, granular -6 to +20 mesh, each grading a minimum of 60 per cent K_2O equivalent, soluble and chemical grade a minimum of 62 per cent K_2O equivalent. [2] Standard includes Special Standard, sales of which were 190 265 t K_2O equivalent in 1984, and 151 982 t in 1985. [3] Chemical sales are included in standard grade sales and totalled 59 045 t in 1985.

- Nil; .. Not available.

TABLE 3. CANADA, POTASH PRODUCTION AND TRADE, FERTILIZER YEARS-ENDED JUNE 30, 1966, 1971, AND 1976-86

	Production[2]	Imports[1,2]	Exports[2]
	(tonnes K_2O equivalent)		
1966	1 748 910	31 318	1 520 599
1971	3 104 782	26 317	3 011 113
1976	4 833 296	16 445	4 314 150
1977	4 803 015	24 289	4 175 473
1978	6 206 542	26 095	5 828 548
1979	6 386 617	21 819	6 256 216
1980	7 062 996	20 620	6 432 124
1981	7 336 973	35 135	6 223 162
1982	6 042 623	25 437	5 400 662
1983	5 378 842	21 846	4 864 219
1984	7 155 599	17 934	6 730 733
1985	7 283 509	17 396	6 784 178
1986	6 519 777	12 837	6 479 678

Source: Potash and Phosphate Institute, Canadian Fertilizer Institute.
[1] Includes potassium chloride, potassium sulphate, except that contained in mixed fertilizers. [2] Change of data source. Prior to 1978 figures were obtained from Statistics Canada.

TABLE 4. CANADA, POTASH PRODUCTION AND SALES IN 1985 AND BY QUARTERS, 1986

	Total (1985)	1986			
		1st quarter	2nd quarter	3rd quarter	4th quarter
	(000 tonnes K_2O)				
Production	6 636.4	1 729.8	1 824.4	1 307.4	1 835.5
Sales					
North America	4 649.9	1 152.3	1 341.3	870.8	929.5
Offshore	1 927.8	578.1	715.1	643.7	675.6
Ending Inventory	1 765.9	1 765.3	1 533.4	1 326.3	1 536.6

Source: Potash and Phosphate Institute.

TABLE 5. CANADA, POTASH SALES BY PRODUCT AND AREA, 1984 AND 1985

		Agricultural					Industrial			Total Sales
		Standard	Coarse	Granular	Soluble	Total	Standard	Soluble	Total	
		(tonnes K_2O equivalent)								
Alberta	1984	536	2 562	20 579	1 366	25 043	2 587	849	3 436	28 479
	1985	207	1 716	22 708	2 964	27 594	5 419	786	6 204	33 798
British Columbia	1984	19	612	4 848	49	5 528	-	-	-	5 528
	1985	(32)	681	5 637	62	6 349	-	-	-	6 349
Manitoba	1984	-	4 567	12 720	970	18 256	-	-	-	18 256
	1985	-	4 543	14 752	1 630	20 925	-	-	-	20 925
New Brunswick	1984	-	5 981	6 581	-	12 562	15	-	15	12 577
	1985	-	-	5 766	-	5 766	-	-	-	5 766
Nova Scotia	1984	47	441	4 056	-	4 544	-	-	-	4 544
	1985	-	(111)	4 964	-	4 854	-	-	-	4 854
Ontario	1984	178	164 842	54 682	2 340	222 042	3 349	4 767	8 112	230 160
	1985	177	149 840	61 247	2 447	213 711	3 797	3 945	7 742	221 453
Prince Edward Island	1984	494	-	5 941	-	6 435	-	-	-	6 435
	1985	24	349	7 913	-	8 281	-	-	-	8 281
Quebec	1984	1 380	34 825	71 879	69	108 152	37	-	37	108 189
	1985	16 627	25 464	67 090	3 350	112 532	176	-	176	112 708
Saskatchewan	1984	396	2 392	7 028	558	10 375	6 980	2 910	9 890	20 265
	1985	-	887	8 636	89	9 612	6 895	2 400	9 294	18 906
Newfoundland	1984	833	-	-	-	833	576	-	576	1 499
	1985	373	-	-	-	373	417	-	417	790
Totals	1984	3 883	216 222	188 314	5 352	413 770	13 540	8 527	22 067	435 842
	1985	17 377	183 365	198 713	10 542	409 996	16 703	7 131	23 833	433 830

Source: Potash and Phosphate Institute.
- Nil. (Brackets) indicate negative quantities.

TABLE 6. CANADA, POTASH INVENTORY, PRODUCTION, DOMESTIC SALES AND EXPORT SALES, 1985

					Export Sales			
			Domestic Sales		United States		Offshore	
	Beginning Inventory	Production	Agricultural	Non-agricultural	Agricultural	Non-agricultural	Total	Total Sales
					(000 tonnes K_2O)			
January	1 543.0	643.9	43.2	2.4	440.2	16.5	143.7	646.0
February	1 634.0	592.9	12.8	2.0	305.0	13.3	203.1	536.2
March	1 684.5	715.5	35.9	1.5	265.8	14.7	152.1	470.0
April	1 876.4	656.0	38.3	1.2	513.6	22.2	187.8	763.1
May	1 805.4	550.9	65.8	1.7	478.2	17.2	198.3	761.2
June	1 699.0	511.8	11.7	2.3	201.9	15.0	176.0	406.9
Sub-total		3 671.0	207.7	11.1	2 204.7	98.9	1 061.0	3 583.4
July	1 859.6	314.5	4.6	2.6	147.5	10.3	113.8	278.8
August	1 735.6	338.0	19.9	1.6	400.1	17.8	163.6	603.0
September	1 587.0	489.0	29.0	1.7	398.6	13.3	176.8	619.4
October	1 520.4	680.2	45.2	2.3	269.6	18.4	160.9	496.4
November	1 654.2	635.5	18.0	2.0	169.8	15.4	111.1	316.3
December[1]	1 876.4	508.2	85.8	2.4	436.9	14.7	140.6	680.4
Sub-total		2 965.4[e]	202.5	12.6	1 822.5	89.1	866.8	2 994.3
Total 1985		6 636.4	410.2	23.7	4 027.2	188.0	1 927.8	6 577.7
1984		7 748.6	413.7	22.1	3 894.8	195.1	2 554.7	7 070.5
% change 1985/84		-14.4	-0.8	+7.2	+3.4	-3.6	-24.5	-7.0

Source: Potash and Phosphate Institute of North America.
[1] Inventory at the end of December 1985 is estimated at 1 765 900 tonnes. Inventory changes are based on shipments and do not exactly match the sales and production records.
[e] Estimated by Mineral Policy Sector, Energy, Mines and Resources Canada.

TABLE 7. CANADA, POTASH INVENTORY, PRODUCTION, DOMESTIC SALES AND EXPORT SALES, 1986

					Export Sales			
			Domestic Sales		United States			
	Beginning Inventory	Production	Agricultural	Non-agricultural	Agricultural	Non-agricultural	Offshore	Total Sales
					(000 tonnes K_2O)			
January	1 565.9	527.8	50.8	1.7	570.6	19.6	130.7	773.4
February	1 597.4	557.6	36.6	2.0	242.6	15.9	252.5	549.6
March	1 581.4	644.4	23.2	1.6	287.9	13.7	195.2	521.6
April	1 765.3	671.7	42.2	1.0	644.5	14.5	254.6	956.8
May	1 491.1	590.0	51.0	1.7	417.5	21.9	274.8	766.9
June	1 356.3	562.8	15.8	1.6	144.0	14.8	182.5	358.7
Sub-total		3 554.3	219.6	9.6	2 307.1	100.4	1 290.3	3 927.0
July	1 532.8	272.9	8.4	0.3	91.6	8.9	246.9	356.1
August	1 442.5	466.2	12.1	1.3	259.5	14.4	148.7	436.0
September	1 510.9	567.5	28.3	1.5	402.5	18.6	248.0	698.9
October	1 326.3	640.1	16.8	1.3	191.9	17.9	199.3	427.2
November	1 529.8	658.1	4.3	0.9	224.8	23.0	180.5	433.5
December[1]	1 759.6	537.3	16.4	1.5	403.2	27.5	295.8	744.4
Sub-total		3 142.1	86.3	6.8	1 573.5	110.3	1 319.2	3 096.1
Total 1986		6 696.4	305.9	16.4	3 880.6	210.7	2 609.5	7 023.1
1985		6 636.4	410.2	23.7	4 027.2	188.0	1 927.8	6 577.7
% change 1986/85		+0.9	-25.4	-30.8	-3.6	+12.1	+35.4	+6.8

Source: Potash and Phosphate Institute of North America.
[1] Inventory at the end of December 1986 was 1 536 610 tonnes.

TABLE 8. WORLD POTASH PRODUCTION

	1981	1982	1983	1984	1985P	1986e
	(000 tonnes K_2O)					
Canada	7 147	5 352	5 930	7 749	6 637	6 700
China	20	26	25	25	30	30
France	1 828	1 706	1 539	1 740	1 750	1 630
Germany Dem. Rep.	3 497	3 200	3 341	3 463	3 465	3 485
Germany, Fed. Rep.	2 591	2 057	2 419	2 645	2 583	2 162
Israel	832	942	929	1 130	1 172	1 255
Italy	175	115	133	127	143	135
Jordan	–	9	168	291	545	660
Spain	728	694	659	677	645	680
U.S.S.R.	8 449	8 079	9 294	9 776	9 900	9 100
United Kingdom	284	240	303	319	337	390
United States	2 156	1 784	1 429	1 564	1 296	1 170
	27 657	24 489	26 163	29 506	28 503	27 397

Sources: International Fertilizer Industry Association Ltd.; U.S. Bureau of Mines and Energy, Mines and Resources Canada.
P Preliminary; e Estimated; – Nil.

TABLE 9. CANADA POTASH, CURRENT SITUATION AND FORECAST

		Actual						Forecast	
		1981	1982	1983	1984	1985	1986e	1987	1990
		(000 tonnes K_2O)							
Capacity		8 060	8 520	9 165	9 315	9 775	10 575	11 070	11 100
Production		7 175	5 216	5 928	7 749	6 636	6 700	7 300	9 100
Capacity Utilization		89%	61%	65%	83%	68%	63%	66%	82%
Sales:		6 337	5 101	6 557	7 071	6 577	7 030	7 320	9 100
of which:	Domestic	332	283	385	436	434	320	420	500
	United States	4 182	3 241	4 146	4 090	4 215	4 100	4 100	4 700
	Offshore	1 823	1 577	2 026	2 545	1 928	2 610	2 800	3 900
End-year stocks		1 308	1 486	862	1 543	1 766	1 540	1 500	1 600
World Production		27 657	24 493	26 176	29 477	28 442	27 500	28 200	31 100
Canada/World Production Ratio		26.0%	21.3%	22.6%	26.3%	23.3%	24.3%	25.9%	29.2%

e Estimated.

TABLE 10. CANADA, POTASH MINES - CAPACITY PROJECTIONS

	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
					(000 tonnes K_2O equivalent)							
PCS												
- Allan (60%)	570	570	570	570	570	570	570	570	570	570	570	570
- Cory	830	830	830	830	830	830	830	830	830	830	830	830
- Esterhazy (25% of IMC)	580	580	580	580	580	580	580	580	580	580	580	580
- Lanigan	690	690	1 240	1 740	1 740	1 740	1 740	1 740	1 740	1 740	1 740	1 740
- Rocanville	1 160	1 160	1 160	1 160	1 160	1 160	1 160	1 160	1 160	1 160	1 160	1 160
Sub-total	3 830	3 830	4 380	4 880	4 880	4 880	4 880	4 880	4 880	4 880	4 880	4 880
CCP	815	815	815	815	815	815	815	815	815	815	815	815
Cominco	655	815	815	815	815	815	815	815	815	815	815	815
IMC (75%)	1 750	1 750	1 750	1 750	1 750	1 750	1 750	1 750	1 750	1 750	1 750	1 750
PPG (Kalium)	1 055	1 055	1 055	1 300	1 300	1 300	1 300	1 300	1 300	1 300	1 300	1 300
PCA	630	630	630	100	-	-	-	-	-	-	-	-
Saskterra (Allan 40%)	380	380	380	380	380	380	380	380	380	380	380	380
Sub-total	5 285	5 445	5 445	5 160	5 060	5 060	5 060	5 060	5 060	5 060	5 060	5 060
Total Saskatchewan	9 115	9 275	9 825	10 040	9 940	9 940	9 940	9 940	9 940	9 940	9 940	9 940
Denison, N.B.	-	200	450	650	780	780	780	780	780	780	780	780
PCA, N.B.	200	300	300	380	380	380	380	380	380	380	380	380
Total New Brunswick	200	500	750	1 030	1 160	1 160	1 160	1 160	1 160	1 160	1 160	1 160
Canada (firm)	9 315	9 775	10 575	11 070	11 100	11 100	11 100	11 100	11 100	11 100	11 100	11 100
(unspecified)	-	-	-	-	-	-	-	-	-	800	1 400	2 000
TOTAL	9 315	9 775	10 575	11 070	11 100	11 100	11 100	11 100	11 100	11 900	12 500	13 100

Note: Capacity means "rated" capacity; under normal conditions Canadian mines operate at about 90 per cent of rated capacity.
- Nil.

TABLE 11. WORLD POTASH CAPACITY, 1984-95

	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
	(000 tonnes K_2O equivalent)											
North America												
Canada	9 315	9 775	10 575	11 070	11 100	11 100	11 100	11 100	11 100	11 900	12 500	13 100
United States[1]	1 700	1 510	1 490	1 430	1 320	1 160	1 010	910	910	1 010	1 185	1 185
Total	11 015	11 285	12 065	12 500	12 420	12 260	12 110	12 010	12 010	12 910	13 685	14 285
Western Europe												
France	2 000	1 800	1 700	1 700	1 700	1 700	1 700	1 500	1 400	1 400	1 400	1 400
Germany, Fed. Rep.	2 700	2 800	2 800	2 800	2 800	2 800	2 800	2 800	2 800	2 800	2 800	2 800
Italy	200	200	200	200	200	200	200	200	200	200	200	200
Spain	800	740	790	800	800	800	800	800	780	680	630	600
United Kingdom	360	360	400	400	400	400	400	400	400	400	400	400
Total	6 060	5 900	5 890	5 900	5 900	5 900	5 900	5 700	5 580	5 480	5 480	5 450
Eastern Europe												
Germany, Dem. Rep.	3 600	3 600	3 600	3 600	3 600	3 600	3 600	3 600	3 600	3 600	3 600	3 600
U.S.S.R.	10 500	10 800	10 075	9 905	10 405	10 730	10 830	11 255	11 755	11 955	12 155	12 255
Total	14 100	14 400	13 675	13 505	14 005	14 330	14 430	14 855	15 355	15 555	15 755	15 855
Asia												
Israel	1 000	1 260	1 260	1 260	1 260	1 320	1 380	1 380	1 500	1 500	1 500	1 500
Jordan	300	550	650	720	760	840	840	840	840	840	840	840
China, People's Rep.	30	30	30	30	30	30	60	80	100	120	120	120
Total	1 330	1 840	1 940	2 010	2 050	2 190	2 280	2 300	2 440	2 460	2 460	2 460
Latin America												
Brazil	-	10	50	100	200	250	300	300	300	300	300	300
Chile	30	30	30	30	30	30	30	30	30	30	50	100
Total	30	10	80	130	230	280	330	330	330	330	350	330
Other	-	-	-	-	-	50	50	50	100	100	150	150
World Total	32 535	33 455	33 650	34 045	34 605	35 010	35 100	35 245	36 000	36 835	37 860	38 530

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[1] The start-up of a mine in Michigan in the 1990s is included.

- Nil.

Rare Earths

D.E.C. KING

Rare earth metals (lanthanides) encompass fifteen chemically similar metals, but two other metals, scandium and yttrium, closely resemble this group and are usually classed with them. The minerals containing these metals are actually not rare, but relatively rare metals such as beryllium, zirconium, columbium, tantalum, thorium and uranium are often found associated with them in nature. The metals were originally classified "rare" because they are seldom concentrated in nature like most other elements and their widespread occurrence in the earth's crust was recognized only in recent times. Moreover, they are difficult to separate from one another and commercial separation plants so far produce very small quantities compared with some other metals, thus, making them at least commercially rare. The term "earth" is a retention of early terminology for insoluble natural oxides.

Lanthanide-bearing minerals contain all members of the rare earth group of elements, but some are classified as the "light" group and the remainder the "heavy" group. Cerium is generally the most abundant element in minerals containing the "light" rare earths, which are also associated with scandium. The "heavy" rare earths are usually found in minerals which often contain substantial proportions of yttrium. The rare earth metals are typically associated with alkaline igneous rocks and as secondary concentrations in placer, beach sand and phosphatic sedimentary deposits. Commercial production has been derived from carbonatite occurrences, placer and beach sand deposits, uranium ores, and phosphatic rocks.

Monazite is a rare earth phosphate that contains nearly 70 per cent rare earth oxides (REO) and about 1.5 per cent yttrium oxide. Placer deposits of heavy mineral sands are the major source of monazite which is usually recovered as a by-product of rutile, ilmenite and zircon mining operations. Only in a few cases have deposits been exploited primarily for monazite; such a deposit in South Africa was the world's major source of monazite from 1953 to 1963. Bastnaesite is a fluorcarbonate of the cerium subgroup which contains about 75 per cent REO and 0.05 per cent yttrium. It has been found in economic quantities in vein deposits, contact metamorphic zones, pegmatites and other igneous rocks. Xenotime, the yttrium phosphate isomorph of monazite is the main source of yttrium and the "heavy" rare earth elements.

World reserves of rare earth metals have been estimated at close to 50 million t of contained rare earth oxides, while annual world consumption is only of the order of 40 000 t of which the U.S. demand is about 22 000 t. The total world demand for yttrium oxide is about 350 tpy. Total samarium oxide demand is approximately 350-400 tpy.

The rare earth elements are used as metals, oxides, halides and other compounds. Because of the difficulty of separating the individual rare earth elements, most industrial applications still employ mixtures of the elements. Originally these mixtures were in the proportions occurring in the ore sources but there is a growing demand for individual rare earth elements or mixtures enriched by one specific element. However, the commercial demand for individual elements hardly ever matches the proportions occurring in ore sources and, therefore, some elements are invariably in oversupply. This tends to spur research into uses for the less popular and more abundant elements. Cerium, neodymium, yttrium and lanthanum are considerably more abundant than thulium, lutetium, terbium, holmium and europium (by anywhere from 20 to over 200 times) and the remaining rare earth elements are of intermediate abundance.

New markets for specific members of the rare earth group of elements have resulted in increased production of all of the rare earth metals from which they must be separ-

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ated because of their natural association in ores. Simultaneously, production costs for some rare earth members, produced as by-products of the refining process, have diminished. Availability and declining costs have been important factors in the development of new uses. There is growing optimism that the rare earth metals industry will expand at a steady rate now that industrial uses are becoming more diverse.

CANADIAN INDUSTRY

While substantial resources of rare earths have been identified in Canada, raw material production in the past has been limited to relatively small outputs of by-product residues from uranium mining and hydrometallurgical operations at Elliot Lake, Ontario. These concentrates were produced from 1966 through 1970 and from 1974 through 1977. Elliot Lake uranium ores are rich in yttrium and "heavy" rare earth elements, and were the world's major source of yttrium concentrate during the first of the two periods noted above. The Elliot Lake ores contain about 0.11 per cent uranium oxide (U_3O_8), 0.028 per cent thorium oxide and 0.057 per cent rare earth oxides.

Denison Mines Limited has been the largest Canadian producer of rare earth concentrates. Denison ceased production of yttrium concentrate in 1978 because its recovery had become uneconomic owing to increased costs of chemical reagents. Marketing of the yttrium concentrate was carried out through Molycorp, Inc. and Michigan Chemical Corporation. However, shipments to the latter company were terminated in mid-1970 when Michigan Chemical experienced difficulty in marketing the product. In September 1985, Denison formed a joint partnership with SM Yttrium Canada Limited (a Japanese financed venture of Shin-Etsu Chemical Co., Handotai Co. and Mitsui & Co., Ltd. of Japan) and Unocal Corporation subsidiary, Unocal Canada Limited, which is an affiliate of Molycorp, Inc. of the United States. The joint venture announced plans to construct a $10 million plant to resume the production of yttrium concentrates from uranium waste solution at a site adjacent to Denison's uranium operation at Elliot Lake, Ontario, at an annual capacity of 150 t Y_2O_3 content. Construction was completed on schedule and plant commissioning began near the end of 1986. The operation is reportedly based on improved process technology which leaves thorium behind in the waste solution and recovers yttrium, rare earths and some remaining uranium. The output of yttrium-rich concentrates is to be shared equally between Molycorp, Inc. and Shin-Etsu for further separation and refinement of the yttrium from other rare earths, including samarium. Even though this production will be equivalent to about 35 per cent of present world demand for yttrium, Shin-Etsu's requirements are expected to exceed this amount.

Rio Algom Limited recovered thorium and rare earth concentrate for a time in the mid-1960s at its Nordic mill, but discontinued this activity upon transfer of uranium milling to the Quirke mill where no thorium and rare earth facilities were installed.

In addition to the large resource in Elliot Lake uranium ores, rare earths are also associated with uranium deposits at Agnew Lake, 65 kilometres (km) east of Elliot Lake (where the REO content is about twice that of Elliot Lake ores), and in the Bancroft area of Ontario.

The Highwood Resources Ltd. property at Thor Lake, located about 100 km south-east of Yellowknife, contains several zones, each composed of somewhat different mineralization. The Lake zone is enriched in tantalum, columbium, rare earths and zirconium, the R zone contains rare earths and beryllium, the S zone is enriched in uranium, thorium and columbium and the T zone contains columbium, uranium and beryllium. The lake zone contains an estimated 70 million t at 3.5 per cent Zr, 1.7 per cent rare earths, 0.4 per cent Nb and 0.03 per cent Ta.

Drilling on the R and T zones identified a beryllium enrichment of about 1.6 million t grading 0.85 per cent beryllium oxide (BeO). In 1985, a 1 600 ft. ramp that was driven into the T zone to obtain a large bulk sample of beryllium-bearing rock, cut a 3 to 10 metre width containing fluocarbonate rare earth minerals assaying 23 per cent lanthanum, 13 per cent cerium, 5.7 per cent neodymium, 0.5 per cent samarium and 0.05 per cent europium oxides. Enriched yttrium levels were found within and between the beryllium zones, indicating nearly a half-million tonnes of rock at 1.3 per cent yttrium oxide (Y_2O_3). Test work on the bulk sample by a laboratory commissioned by Highwood indicated successful flotation recovery of beryllium and yttrium. In the fall of 1986, Highwood entered into an agreement with Hecla Mining Company under which

Hecla undertook to finance further metallurgical and feasibility studies in order to obtain an equity interest in Highwood's Thor Lake property. Under this arrangement, concentrates have been subjected to further metallurgical test work for the separation of beryllium and other constituents and for overall project evaluation, which the company hopes will enable an early production decision.

The Strange Lake deposit, owned by Iron Ore Company of Canada (IOC), is located near Lac Brisson on the Quebec-Labrador boundary and approximately 250 km northeast of Schefferville. It is reported to contain a large tonnage of yttrium and zirconium as well as large quantities of columbium, beryllium and rare earth elements. The deposit, discovered by IOC in 1979 in a follow-up to government surveys, is located at a shallow depth and is amenable to open-pit mining. IOC conducted a metallurgical, engineering and market evaluation of this property during 1984 but suspended all work on the project in 1985.

Significant quantities of rare earths are found in a number of Canadian pyrochlore-bearing carbonatite deposits, such as the Cambior inc. mine near St. Honoré, Quebec and on the Manitou Islands, Lake Nipissing, Ontario. Cambior was examining the grade and mineralogy of its rare earth zone, which is close to its niobium deposit, in order to assess the commercial possibilities.

Phosphate formations in western Canada contain small quantities of rare earths, as do Florida phosphates imported into Canada for the production of phosphoric acid. Other potential sources include apatite-rich carbonatites in Ontario and Quebec. Rare earth elements, primarily the light element group, are associated with apatite in the Nemegos No. 6 magnetite deposit, which is located in the Chapleau area of Ontario.

Sherritt Gordon Mines Limited has been producing samarium-cobalt alloy powders at Fort Saskatchewan, Alberta since 1980 as a means of marketing cobalt with added value. Through continued research and development, Sherritt has improved the processing technology that was originally purchased from Canadian General Electric Company Limited in 1979, to the point that in 1984 its $SmCo_5$ (1-5) type alloy powder was of fully competitive quality. Production of type 1-5 alloy powder is in tonnage quantities, but it is currently limited to some extent by a short samarium supply. Hitachi Magnetics Corp. and Th Goldschmidt AG are major producers of samarium-cobalt magnet materials, each with capacity many times the size of Sherritt's. However, Sherritt has been gradually improving its position in this field by its successful technological developments, with emphasis on the Sm_2Co_{17} (2-17) class of magnet alloy. This 2-17 alloy, which nominally contains 24 per cent samarium, compared with 34.5 per cent in the 1-5 type, has a lower resistance to de-magnetization but a higher energy per unit volume (energy product) than the type 1-5. Research on the production of magnets from 2-17 powder has already been successful to the point that Sherritt's technology, involving heat treatment, chemistry and microstructure control, has been licensed to Hitachi. In addition, Sherritt has developed 2-17 magnet alloy powder with energy products of about 30 mega gauss oersteds, about 10 per cent higher than competitive Sm-Co materials.

WORLD INDUSTRY

Total world production of rare earth minerals in 1985 was estimated to have been about 47 000 t of contained rare earth oxides, of which bastnaesite from the United States accounted for 22 000 t. The remainder was supplied by Australia (8 250 t), China (10 000 t), India (2 200 t), Malaysia (2 000 t), Brazil (1 100 t) and other countries (1 800 t).

Estimates of rare earth minerals reserves by the U.S. Bureau of Mines (USBM) indicate about 5 million t of rare earth oxide content in North America, and a world total of about 48 million t, including the reported 38 million t of China. Substantial yttrium reserves exist in the United States (47 000 t). India (50 000 t), Australia (5 200 t), Canada (4 000 t) and Brazil (1 500 t).

Although the consumption of rare earths and yttrium are increasing strongly, world reserves are clearly more than sufficient to meet foreseeable demand.

The rare earth elements are principally extracted from two minerals, monazite and bastnaesite. Most of the world's bastnaesite production is from a mine at Mountain Pass, California, which is owned and operated by Molycorp, Inc. Very large reserves of bastnaesite also exist in China which has the processing capability to produce separate and pure rare earth elements. China's bastnaesite occurs in a massive iron ore deposit in Inner Mongolia.

Monazite is usually recovered commercially from heavy mineral beach sands as a co-product with rutile, ilmenite and zircon. It is found in a number of countries but the main producing countries are Australia, United States, India, Brazil, and Malaysia. Australia produces over one half of the total world output of monazite but so far possesses no processing capacity. Both India and Brazil prohibit the export of monazite because of its thorium content. Accordingly, monazite is processed in these countries to remove thorium and produce mixed rare earth compounds.

The United States, Japan and France are the leading processors of rare earth minerals, and the two companies Molycorp, Inc. in the United States and Rhône-Poulenc SA of France dominate this industry. Generally speaking, most of the output from the United States and Japan is from bastnaesite while about one half of the world's output of monazite is processed in western Europe. The United States is also an important processor of monazite. Consumption of rare earth compounds, alloys and individual metals occurs mainly in the United States, Japan and western Europe.

In Western Australia, a new company TiO_2 Corporation NL is planning to develop new heavy mineral sand deposits at Jurien Bay and Cooljarloo, which are 260 km north of Perth. The latest publication of proven and probable reserves indicated 12 million t of contained heavy minerals above a 2 per cent cut-off grade at Cooljarloo and a further 2 million t at Jurien. The heavy minerals contain ilmenite mainly, with leucoxene, rutile, zircon, and monazite in lesser amounts. Planned output of 113 000 tpy of ilmenite has been quoted but the probable quantity of co-product monazite has not been mentioned. In the East Kimberley region of Western Australia, West Coast Holdings Ltd. reported proven reserves of 4.29 million t of strategic metals including niobium, tantalum, zirconium, gallium, heavy rare earths and yttrium. A hydro-metallurgical process has been developed in the United Kingdom to produce refined products for the economic metals present. Subject to the findings of marketing, environmental impact and feasibility studies that were under way, the owner envisaged an operation that could produce 1 500 t of niobium oxide, 3 500 t of zirconium oxide, 420 t of yttrium oxide, 340 t rare earth oxides as well as tantalum, hafnium, and gallium.

Kerala Minerals and Metals Ltd. of India plans to add a new mineral separation plant in 1987 at Chavara in Kerala State for the production of 1 800 tpy of monazite. A new source of minerals containing monazite was discovered in the coastal beach sands of the Thanjavur district in India.

China has become a significant producer of rare earth compounds and alloys, with the potential to create a significant impact on the rare earth market. China has developed all levels of processing and produces a full range of rare earth products, including concentrates, intermediate compounds and pure metals and compounds. Chinese domestic consumption is increasing, especially as iron and steel alloying additions and in petrochemical production. China sells rare earth glazed tile and ceramics to more than 30 countries, and has begun development of technology for rare earth permanent magnets. Japan has undertaken joint development projects with China and has been importing an increasing amount of rare earth concentrates in return. For example, China has replaced Malaysia as the main source of yttrium for Japan and it has been exporting rare earth materials at competitive prices. The main base of Chinese rare earth production is at Baotou, where 50 per cent of China's huge reserves are located in iron ore and associated rock. Ore dressing concentrates the crude ore to 60 per cent REO. Processing plants convert the concentrate to chloride, ferrosilicide, pure compounds and metals.

Molycorp separates and refines rare earths at its mine site and main processing plants in Mountain Pass, California, and produces high purity oxides and compounds at Washington, Pennsylvania, where a facility was completed in 1980 to produce samarium cobalt alloys. The company has other production facilities for high purity compounds at York, Pennsylvania and at Louviers, Colorado where high purity yttrium oxide is made from xenotime.

Davison Specialty Chemicals Division of W.R. Grace and Company processes monazite almost solely for its own zeolite-rare earth catalyst production at its 23 000 tpy facility at Curtis Bay, Maryland, and at its plants at Lake Charles and South Gate, California.

Ronson Metals Corporation produces mischmetal and, through its subsidiary Cerium Metals Corporation, alloys of cerium, lanthanum and didymium (a commercial mixture of rare earth metals enriched in neodymium and praeseodymium), cerium free mischmetal, and high-purity samarium metal. Ronson began to produce neodymium metal in 1984 for magnet manufacture.

Reactive Metals and Alloys Corporation produces specialty silicon alloys, rare earth silicide and mischmetal at its West Pittsburgh plant.

Rhône-Poulenc SA has its main operation at La Rochelle, France where it has an annual production capacity of about 4 600 t of light rare earth elements and 370 t of the heavy elements from imported monazite. The company also operates a 4 000 tpy rare earth separation and refining plant at Freeport, Texas. Monazite for Rhône-Poulenc's operations is normally from Australia but during 1986 the company acquired the tailings and ore reserves, rich in rare earths and yttrium, of a defunct iron mine at Mineville, New York State. Plans included the construction of an extraction plant to produce several hundred tpy of rare earth oxides, with production to begin in 1987. Rhône-Poulenc had also announced in 1985 its intention to increase rare earth capacities in La Rochelle, France, and Freeport, Texas, at a cost of $22 million.

Th Goldschmidt AG of West Germany produces a range of alloys based on rare earth elements with cobalt, iron and other transition elements. It is a large producer of samarium-cobalt-magnet alloys and it also produces neodymium, its compounds and alloys.

Treibacher Chemische Werke AG of West Germany is the leading world producer of mischmetal.

Rare Earth Products Ltd., a division of Johnson Matthey Chemicals Limited is a relatively small producer of the full range of pure rare earth metals and compounds at Widnes, England. London and Scandinavian Metallurgical Co. Ltd., a subsidiary of Metallurg Inc., produces cerium oxide polishing powders, mischmetal and rare earth silicide in the United Kingdom.

There are about a dozen companies in Japan which produce a comprehensive range of rare earth metals, alloys and compounds for all categories of consumption. Since Japan has no domestic sources of rare earths, its government was supporting Japanese companies in joint exploration ventures in China, Malaysia and the United States, and in the development of improved extraction and separation technology. Mitsubishi Chemical Industries Ltd. has two yttrium joint venture projects in Malaysia. It announced in 1986 a joint venture agreement with Reactive Metals and Alloys Corporation (Remacor) to research, develop and market neodymium metal, neodymium alloys and other rare earth metal products which are to be produced at Remacor's West Pittsburg facility and supplied to General Motors Corporation and other automobile and magnet manufacturers. The joint venture's name was to be Neomet Corporation. Shin-Etsu Chemical Co. and W.R. Grace and Company also announced a joint venture whereby Grace was to produce separated rare earths, including samarium and other medium and heavy rare earths, in the United States at the Chattanooga, Tennessee, plant of its Davison Specialty Chemical Division. Davison's plant was being expanded and will employ separation technology licensed from Shin-Etsu when it begins production in early-1987. Shin-Etsu also started work in 1986 on a rare earth separation and refining plant at Takefu in Japan. The plant is to begin production in the first quarter of 1987 and is to have an annual capacity of 100 t of product. It will process one half of Denison's 125 t output of yttrium concentrate and approximately the same quantity of medium to heavy rare earth materials from W.R. Grace. Sumitomo Metal Mining Co. Ltd., which began production of the new neodymium boron iron magnets about three years ago, formed a joint venture with Rhône Poulenc Minérale Fine, a division of France's largest chemical group Rhône-Poulenc SA, for the manufacture and marketing of rare earths in Japan. The new company, Nippon Rare Earths, will initially sell and eventually manufacture rare earths from imported raw material intermediates and concentrates.

CONSUMPTION AND USES

Rare earths have unique properties which enable them to be employed in distinctly different ways. Because of the similarity of their chemical and some of their physical properties, mixtures of rare earths as alloys or compounds can be effectively used in certain types of applications. However, other applications depend on individual chemical and nuclear properties, and require specific rare earth elements without more than a minor quantity of the other rare earths present. There is a trend towards the greater use of specific rare earths and of mixtures enriched in individual rare earth components.

Rare earth mixtures are used in catalysts, master alloys, other alloys and glass polishing compounds. Individual rare earth metals or compounds are used in magnetic materials, phosphors, neutron capture applications, glass, ceramics and other uses.

Mischmetal, (an alloy containing a mixture of light rare earths generally in the ratio found in the ore), ferrocerium, and cerium silicide are added to some grades of high-strength low-alloy (HSLA) and stainless steels to effect sulphide shape control. This practice has been somewhat in decline in recent years because of a trend towards greater removal of sulphur during steelmaking. However, the need for weldability in these steels appears to be retarding the trend towards ever-lower sulphur levels, which in some steels are as low as 0.002 per cent. The decline in the use of rare metals in steels and in nodular irons for graphitization of carbon, accordingly, appears to be levelling off and showing signs of recovering.

The development of magnesium alloys with improved hot strength is an example of the trend towards the greater use of specific rare earth metals. Magnesium Elektron Ltd. of the United Kingdom has progressively improved the properties of its range of magnesium alloys, firstly by enriching rare earth additions with yttrium, and later with neodymium and other elements. The rare earth additions combine to form precipitates which strengthen or lock the alloy crystals in place under load. Another alloying application is a 0.05 per cent mischmetal addition to "Galfan", a galvanizing coating containing 5 per cent aluminum in zinc.

Rare earths are added to catalysts used in the cracking operation of petroleum refining of heavy crude oils. Rare earths modify the surface activity of other compounds, and are added as natural or cerium-depleted mixtures of rare earth chlorides to zeolite catalysts. They have only recently been available in tonnages large enough to satisfy this large market. However, the production of higher octane unleaded gasoline has resulted in a considerable reduction in rare earth content in the catalysts. Automobile exhaust systems could be another substantial area for the use of natural rare earth mixtures (cerium-rich) because of their ability to stabilize the alumina matrix which carries the active catalysts. Rare earths are also used in many other catalytic applications.

Glass polishing and decolourizing are two distinctly separate applications for rare earths. Natural mixtures of rare earth oxides, high in cerium, are very effective as polishing powders in high-quality optical and plate glass, and mirror applications. The use of plastic lens systems in popular lightweight cameras has reduced demand to some extent, but the increasing demand for video tubes with glass screens could offset this.

Cerium oxide, in small quantities, is an effective glass decolourizer. Owing to its ability to absorb ultraviolet light, cerium oxide is used in the manufacture of transparent bottles to inhibit food spoilage. Neodymium, praeseodymium, erbium and holmium are effective in welders' goggles, sunglasses and optical filters because of their absorption characteristics. Lanthanum, yttrium, gadolinium, and ytterbium oxides are used in optical lenses to increase the refractive index of the glass. A recent development involves light polarization and electro-optic switching in pilots' protective goggles for automatically blocking the brightness of a nuclear flash. The switching device is based on ceramic lead-lanthanum zirconate-titanate. For glass colouring, praseodymium imparts a yellow-green colour, neodymium a lilac, europium an orange-red, and erbium a pink colour. Glass applications account for about 30 per cent of total world rare earth consumption.

Rare earths are also widely used as colouring agents in household ceramics. Praseodymium imparts a brilliant yellow colour to ceramic tile glaze. Yttrium, cerium neodymium and erbium are also associated with this usage.

Many other important uses for rare earths exist, which so far use only small quantities of the elements. These include laser, nuclear, bubble memory, hydrogen storage, microwave, medicine, jewellery, solar energy, temperature measurement and various other applications. Among the individual rare earths whose sharp line emissions are effective in laser applications, neodymium in an yttrium-bearing host material is the most commonly used.

Nuclear uses include a role as neutron absorbers in fast breeder reactors. The very high captive cross sections for thermal neutrons of europium, samarium, dysprosium and gadolinium are utilized when used in reactor control rods. In another nuclear application, gadolinium oxide, which has the highest neutron absorption of any element, is used in uranium fuels to reduce uranium consumption and improve the energy output.

Magnetic bubble memory films for data storage and processing promises to be an important new application, particularly for gadolinium in the form of a gadolinium-gallium garnet. So far the full potential of high efficiency bubble memory systems has not been attained. It may take further years to reach commercial production before such systems can compete with comparatively low cost and flexible floppy disc systems. Gadolinium gallium garnets are gaining use in high capacity magnetic bubble domain devices.

Hydrogen storage is based on the ability of alloys such as lanthanum-nickel to absorb hydrogen at appropriate temperatures and pressures. Lanthanum-nickel can absorb up to 400 times its own volume of hydrogen. However, the need for large scale hydrogen storage has not yet arrived.

Garnets containing yttrium, holmium or gadolinium are used in various electronic components to filter microwaves in radar, ovens and telecommunications. Circulators and phase shifters utilize the low loss magnetic properties at high frequencies of holmium and gadolinium garnets, while yttrium garnets are now used in high output laser oscillators.

There is a potentially large growth application for yttrium and ytterbium oxide in partially stabilized ceramic zirconia, and yttrium may also be used as the binder in silicon nitride and sialon. The stabilization, which can also be achieved less satisfactorily using magnesia or calcium oxide, toughens the zirconia for wear, heat and corrosion resistance uses. Current applications include extrusion dies, valves and pump parts, and there is active interest in its future use in the wearing surfaces in diesel engines, which would significantly enlarge the market for partially stabilized ceramic zirconia.

Individual rare earth oxides and fluorides are used in significant quantities in carbon-arc lamps where a high intensity white light is desirable. A new type of fluorescent lamp is now on the market that emphasizes three narrow spectral bands around the blue-violet, green and orange-red wavelengths to produce a synthesized white light of great brightness. The new light uses rare earth phosphors of europium, yttrium, cerium and terbium in combinations with magnesium aluminate.

High-value applications exist in the electronics field where individual rare earth oxides are used as phosphors in colour television tubes, in temperature-compensating capacitors and in associated circuit components. Although the volume of europium and yttrium oxides used in colour television phosphors is comparatively small, the value is disproportionately large because of the high degree of purity required in this application. Europium is used as an activator in a yttrium host material to provide the primary red colour. Other activators are cerium, europium and terbium while other host materials are lanthanum and gadolinium. Phosphors utilizing terbium or thulium as activators in lanthanum and gadolinium hosts are now being used in X-ray intensifying screens to produce sharper images with indirect visible light.

The development of rare earth-cobalt magnets set the trend in broadening the demand for individual rare earths in tonnage quantitites. Samarium-cobalt permanent magnets have about four times higher energy product than Alnico magnets and the consequent application of lighter weight magnetic components has played an important role in miniaturization. The volatility of the cobalt market, the relative scarcity of samarium and high cost of samarium cobalt alloys has tended to constrain the expansion of these magnets, and the new neodymium-boron-iron (NdBFe) magnets will also supplant many applications for samarium-cobalt. The neodymium-boron-iron alloys have about 25 per cent higher energy product than the samarium-cobalt alloys, and have advantages in price since neodymium is more abundant and cheaper than samarium, and iron is cheaper and its market more stable than cobalt. However, neodymium-boron-iron alloys tend to lose their magnetism more readily than samarium-cobalt at elevated temperatures, and they are also prone to rusting. Therefore, there will continue to be many special applications for samarium-cobalt magnets which the new alloys cannot fill. Rare earth based magnets are usually fabricated by powder metallurgical methods that facilitate the procedure for inducing a high magnetic flux. Plastic samarium-cobalt magnets have also been successfully developed in Japan. High-strength permanent magnets are used in electric motors, generators, meters, speakers, and frictionless bearings.

The permanent magnet industry has become an active and visible business. Growth for the past 20 years has averaged 10-11 per cent per year and promises to exceed this rate over the next five years with the growing introduction of rare earth permanent magnets into motors, actuators, loudspeakers, levitation applications, medical scanners and many other applications. Since about 90 per cent of the magnet business is still supplied by the low-price low-strength ferrites, there is considerable scope for market penetration by high strength rare earth magnets, provided the cost is competitive, because of magnet and magnetic part size reduction (i.e., if the so-called bucks-per-flux ratio is lower). The attraction of new firms into the industry, the expansion of business and the periodic announcements of joint ventures appear to indicate that re-structuring is taking place. A general shift since the early-1970s has seen the relative production rates of the United States and Japan swing from approximately even quantities to about 30 per cent and 40 per cent, respectively, of total world outputs. In the United States, Delco Remy Division of General Motors Corporation was reported to be building a new magnet manufacturing plant at Anderson, Indiana, and planned to include a new starter motor based on NdBFe magnets in GM's 1986 model cars. Industrial Drives Div. of Kollmorgen Corporation incorporated NdBFe magnets in a new line of brushless motors for robots, machine tools, transfer lines and other automation. At present, brushless motors only have 10 per cent of this market but the cost disadvantage is narrowing. Thomas & Skinner Inc. plans to expand its subsidiary Electron Energy Corp. by 50 per cent for the production of samarium-cobalt magnet alloys.

Currently, there is sufficient neodymium capacity to handle the growing demand for NdBFe magnets and producers are prepared to expand capacity in the next few years if growth is as expected. Presently, NdBFe has only about 1 per cent of the rare earth magnet market but some experts say that penetration could rise to about 33 per cent within the next 5 years. Processors of neodymium metal include Molycorp, Inc., Ronson Metals Corporation, Rhône-Poulenc Inc. and Research Alloys and Chemical Corp.

Since the development of samarium-cobalt magnets, samarium now accounts for nearly two thirds of total consumption of high purity individual rare earth metals. The further growth in demand for rare earth based magnets seems assured. Neodymium-boron-iron magnets are produced by Sumitomo in Japan, Crucible Magnetics Div. of Colt Industries Inc. and General Motors Corporation in the United States, and Magnetic Materials Group in the United Kingdom. General Motors Corporation in the United States is also developing neodymium-boron-iron magnets for motors to operate windshield wipers, electric windows and car seats, and for generators and large induction motors.

MARKETS AND PRICES

Industry does not consume rare earth metals in the natural as-mined ratios. However, since about 96 per cent of rare earths are consumed as mixtures, some flexibility can exist for satisfying demands for individual rare earths by extracting individual metals from intermediate mixtures. Thus, the production of neodymium, one of the more plentiful rare earths, could be increased without necessarily increasing mine production, by increasing the capacities of the separation processes. This would be less possible for the scarcer rare earths like samarium. At the present time, samarium is in such short supply that samarium-cobalt alloy producers receive allocations from suppliers. Supplies are also very tight for europium, yttrium and terbium while gadolinium is in surplus. Neodymium demand has not yet grown as fast as expected, but the demand is strong for dysprosium which is added to NdBFe magnets to raise the curie point (improve heat resistance). The forecasts of overall rare earth growth in the United States is slightly less than 3 per cent per year of which separated rare earths are 3-5 per cent, samarium 10-20 per cent and neodymium 10-20 per cent. United States mischmetal demand has declined due to the lack of orders for pipeline steel. Japanese forecasts to the year 2000 for yttrium, lanthanum, cerium and europium average 13 per cent compounded annually. However, the actual growth of yttrium demand in Japan in the last several years has run at 35 per cent per year, cerium decolorizer 13 per cent, samarium oxide more than 200 per cent, rare earth magnets 35 per cent, and lanthanum about 20 per cent, while mischmetal demand has been static.

Because of their superior temperature tolerance, samarium-cobalt magnets are expected to continue to grow in demand at the rate of about 5 per cent per year, allowing for the expected incursion by neodymium-boron-iron magnets. Within the estimated 5 per cent growth rate, 2-17 growth would be relatively high, possibly 10 per cent to 20 per cent per year, which would more than offset the expected reduction in usage of the older 1-5 type, estimated to decline by 5 per cent to 15 per cent per year.

Prices have reflected the high growth rates of samarium oxide, increasing from about $US 37.50 per pound in mid-1986 to $42.50 per pound at 1986 year-end and indicating a further increase in the future. Likewise yttrium concentrates which were about $9 per lb. of Y_2O_3 content about 8 years ago, were selling for $50 per lb. at the end of 1986.

TABLE 1. RARE EARTH ELEMENTS

Atomic No.	Name	Symbol	Abundance in Igneous Rocks	Oxide	Per Cent Rare Earth Oxide in Total Rare Earth Oxide of Minerals				
					Bastnaesite California	Monazite S. Carolina	Monazite Australia	Xenotime Malaysia	Uranium Residues Elliot Lake, Ont.
	(Light rare earths)		(parts per million)						
21	Scandium	Sc	5.0	Sc_2O_3	-	-	-	-	-
57	Lanthanum	La	18.3	La_2O_3	32.0	19.5	23.0	0.5	0.8
58	Cerium	Ce	46.0	CeO_2	49.0	44.0	45.5	5.0	3.7
59	Praseodymium	Pr	5.5	Pr_6O_{11}	4.4	5.8	5.0	0.7	1.0
60	Neodymium	Nd	23.8	Nd_2O_3	13.5	19.2	18.0	2.2	4.1
61	Promethium	Pm	(Not measurable)	Pm_2O_3	-	-	-	-	-
62	Samarium	Sm	6.5	Sm_2O_3	0.5	4.0	3.5	1.9	4.5
63	Europium	Eu	1.1	Eu_2O_3	0.1	0.2	0.1	0.2	0.2
64	Gadolinium	Gd	6.3	Gd_2O_3	0.3	2.0	1.8	4.0	8.5
	(Heavy rare earths)								
39	Yttrium	Y	28.0	Y_2O_3	0.1	3.0	2.1	60.8	51.4
65	Terbium	Tb	0.9	Tb_4O_7		0.2		1.0	1.2
66	Dysprosium	Dy	4.5	Dy_2O_3		1.3		8.7	11.2
67	Holmium	Ho	1.1	Ho_2O_3		0.1		2.1	2.6
68	Erbium	Er	2.5	Er_2O_3	0.1	0.5	1.0	5.4	5.5
69	Thulium	Tm	0.2	Tm_2O_3		-		0.9	0.9
70	Ytterbium	Yb	2.6	Yb_2O_3		0.2		6.2	4.0
71	Lutetium	Lu	0.7	Lu_2O_3		-		0.4	0.4
	Total		153.0		100.0	100.0	100.0	100.0	100.0

- Nil.

TABLE 2. CANADIAN SHIPMENTS OF RARE EARTH CONCENTRATES

	Y_2O_3 Concentrates (kilograms)	Values ($)
1978-86	-	-
1977[1]	30 400	..
1976[1]	26 308	..
1975[1]	34 927	..
1974	39 366	..
1973	..	..
1972	-	-
1971	..	..
1970	33 112	657,000
1969	38 756	671,500
1968	51 406	936,067
1967	78 268	1,594,298
1966	9 400	130,223

Source: Statistics Canada.
[1] Annual Reports, Denison Mines Limited.
.. Not available; - Nil.

PRICES

The December 1986 issue of "Industrial Minerals" quotes the following prices for concentrates of rare earth minerals:

Bastnaesite concentrate 70% leached, per lb. REO	$US 1.05
Monazite, minimum 55% REO, tonne, f.o.b. Australia	$A 850.00-900.00
Yttrium concentrate 60% Y_2O_3 f.o.b. Malaysia per kg	$US 46.00

REO Rare earth oxides; f.o.b. Free on board.

Prices for rare earth oxide and metal ingots, as quoted in the December 21, 1986 issue of "American Metal Market", were:

Rare earth oxides, U.S. dollars per lb., one-lb. lots

	Per cent	$US
Cerium	99.9	8.00
Europium	99.99	725.00
Gadolinium	99.9	55.00
Lanthanum	99.99	7.00
Neodymium	99.9	40.00
Praseodymium	96	16.80
Samarium	96	40.00
Yttrium	99.99	52.50

At the end of 1986, prices of rare earth metal ingots in U.S. dollars per lb. for minimum lots of 100 lb. f.o.b. shipping point were:

	Per cent	$US
Cerium	99	21.00-57.00
Lanthanum	99	27.50-45.00
Samarium		97.27
Mischmetal	99.8	4.90-5.60
Praeseodymium		109.10

Rhenium

W. McCUTCHEON

The most important use for rhenium is in bimetallic catalysts for the production of low-lead and lead-free gasolines. In petroleum refineries, bimetallic rhenium-platinum (Re-Pt) catalysts are usually more economical than monometallic platinum catalysts. Most refineries have already switched to Re-Pt catalysts but demand could increase further as refiners prepare for stricter limits on lead content in gasoline in many countries. Once the refiners complete the switchover to new catalysts, the growth in the rate of demand is likely to decrease.

CANADIAN DEVELOPMENTS

The Island Copper mine is the sole producer of rhenium in Canada. It is owned by Utah Mines Ltd., a subsidiary of Utah International Inc., wholly owned by The Broken Hill Proprietary Company Limited of Australia.

Island Copper, a copper-molybdenum operation near Port Hardy on Vancouver Island, British Columbia, began production in 1972. The ore occurs mainly in altered volcanic rocks and in this respect differs from the porphyry copper deposits which are the major source of rhenium in the United States and Chile. During the milling of copper-molybdenum ore, the rhenium reports to the molybdenite concentrate and averages about 1 100 parts per million (ppm) in the concentrate. With the present technology, the recovery of rhenium from concentrates ranges from about 50 to 60 per cent.

Until late 1983, the rhenium contained in concentrates was treated at the smelters on a toll basis and the recovered rhenium was returned to the company as perrhenic acid for subsequent upgrading and sale. Since 1984, Island Copper has sold the contained rhenium with the molybdenite concentrates.

Rhenium has also been identified in the porphyry copper ores of Lornex Mining Corporation Ltd., Brenda Mines Ltd. and Gibraltar Mines Limited in British Columbia. Molybdenite concentrates produced from these mines average 250 ppm, 90 ppm and 50 ppm of rhenium, respectively. Future recovery of rhenium from these operations will depend upon rhenium prices.

No data is available on Canadian consumption of rhenium but the consumption pattern is believed to be similar to that of the United States, with rhenium-platinum (Re-Pt) catalysts accounting for most of the consumption.

WORLD DEVELOPMENTS

Commercial sources for rhenium are molybdenite concentrates, recovered from the treatment of low-grade porphyry copper ores in several countries, and from sedimentary copper deposits in the U.S.S.R. The rhenium content of copper porphyry ores is relatively low, being only a few ppm, whereas the molybdenite concentrates produced from these ores have a rhenium content ranging up to 2 000 ppm. Rhenium has also been identified in certain platinum group metals and ores of manganese, tungsten and uranium, but in concentrations too low to be of economic significance under the present technology and price structure.

United States rhenium production statistics are confidential. The United States Bureau of Mines estimates that the rhenium content of ores mined but not necessarily recovered in the United States in 1986 was about 4.5 t. U.S. consumption in 1986 was estimated at approximately 6.4 t. World consumption is not well documented.

Cyprus Minerals Company is believed to have been the only U.S. company recovering rhenium in 1986. Other installations capable of recovering rhenium but believed to have been idle in 1986 include those of the Kennecott Corporation near Salt Lake City; M&R Refractory Metals, Inc. in New Jersey; Molycorp, Inc. in Pennsylvania; and S.W. Shattuck Chemical Co., Inc. in Denver.

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Chile, which has become the world's largest copper producer, is the largest western world producer of rhenium, with 1985 production estimated to be 5 t from domestic and imported sources. Mine production of Corporacion Nacional del Cobre de Chile (Codelco-Chile) in 1985 is estimated at 3.3 t. Prior to 1974, rhenium was exported from Chile in molybdenite concentrates to the United States and elsewhere. Chile then began to export ammonium perrhenate to the United States. Since 1979, Codelco has had a tolling contract with Molibdenos y Metales S.A. (Molymet) for the recovery of rhenium.

Rhenium is recovered from copper porphyries mined in Iran, Peru, the U.S.S.R., Canada, the United States and Chile. In the U.S.S.R., some rhenium is recovered from the Dzhezkazgan sedimentary copper deposit in Kazakhstan. Small amounts of rhenium have been produced in the past by Zaire, Bulgaria, the Democratic Republic of Germany and Poland.

Besides the United States and Chile, countries having metallurgical plants for the recovery of rhenium are the U.S.S.R., Sweden, France, the United Kingdom and the Federal Republic of Germany. Most recover rhenium from imported molybdenite concentrates.

Chile is believed to be the largest exporter of rhenium in the form of ammonium perrhenate. The Federal Republic of Germany is believed to be the largest exporter of rhenium in metal form. The United States is the largest importer of rhenium in both forms.

USES

The most important use for rhenium is in Re-Pt catalysts for the production of low-lead and lead-free, high-octane gasolines. About 90 per cent of United States consumption is directed towards this use. Other uses for Re-Pt catalysts include the production of toluene, benzene and xylene.

The bimetallic Re-Pt catalyst (usually 0.3 per cent Re, 0.3 per cent Pt and 99.4 per cent alumina) generally gives superior performance compared to monometallic platinum catalysts: it can be easily regenerated, is more productive, tolerates greater impurity levels and has a longer life. Hence, it has gradually replaced most monometallic catalysts used in petroleum refining since its commercial introduction in 1969.

Rhenium is highly refractory, having a melting point of 3 180°C, second to that of tungsten, and maintains strength and ductility at high temperatures. Its density of 21 g/cm^3 is exceeded only by that of the platinum group metals. Rhenium has good corrosion resistance to halogen acids. Alloyed with tungsten or molybdenum, rhenium improves the ductility and tensile strength of these metals. The stable oxide film on rhenium does not appreciably increase electrical resistance and this property, plus good resistance to wear and arc corrosion, makes the metal ideally suited for electrical contacts.

Rhenium is also used in filament alloys, heating elements, electrical contacts, metallic coatings, high temperature nickel alloys, and as an alloy with tungsten for use as a catalyst to oxidize SO_2 to SO_3 for the manufacture of sulphuric acid.

TECHNOLOGY

Rhenium is recovered from flue gases emitted from the roasting of molybdenite concentrates. Under properly controlled temperatures, rhenium volatilizes as rhenium heptoxide (Re_2O_7), a compound which is water soluble and can be recovered by subjecting flue gases to wet scrubbing. The rhenium is extracted from this solution as ammonium perrhenate (NH_4ReO_4) by ion-exchange resins or by solvent extraction. Perrhenic acid ($HReO_4$) is also an important commercial product of rhenium. Rhenium metal powder (99.99 per cent pure) is produced by the reduction of NH_4ReO_4 with hydrogen. The powder is pressed and sintered into bars which are cold-rolled to form various shapes. The cost of producing rhenium metals and salts is high. Research has been directed toward the development of a hydrometallurgical process to recover molybdenum and rhenium from molybdenite concentrates in order to increase recovery and reduce production costs.

PRICES

Rhenium prices rose from a fairly stable base of about $US 600/lb. through the 1960s and 1970s to over $2,500/lb. in May 1980. Prices then fell sharply over the next three years to the $US 350 to $US 250/lb. range. By the latter half of 1986, prices for rhenium contained in rhenium perrhenate increased from $US 175 to $US 230/lb. as refiners increased their stock of catalysts. With increasing restrictions on the lead content of gasoline in many countries, demand for rhenium is apparently increasing rapidly as refiners change facilities to allow increased production of lead-free and low-lead gasolines. As changes are completed, demand and prices are likely to fall.

OUTLOOK

Rhenium has been used industrially only for a short period and has not developed a clearly defined growth pattern. Its limited supply inhibits the development of new uses. The only source is rhenium contained in molybdenite concentrates recovered from porphyry copper ores. Under present technology, the recovery of molybdenite from the processing of copper ores varies considerably but is relatively low. Similarly, the recovery of rhenium from molybdenite concentrates is about 60 per cent. Any improvement in either recovery would increase the supply. Canadian rhenium production is likely to continue until the early 1990s, at which time Island Copper's ore will have been depleted.

Not all molybdic oxide producers recover rhenium from molybdenite concentrates due to the high capital costs of a recovery plant. These molybdic oxide operations are new potential sources of rhenium, given a stable price pattern that would justify recovery plants.

In the medium term, the major use of rhenium will continue to be in bimetallic platinum-rhenium catalysts. Future growth in this use is expected to be much lower than in the 1970s, as the market becomes saturated and technical advances extend catalyst life and permit higher rates of recycling. Future development of alternative catalysts could result in substitution away from Re-Pt catalysts.

In the longer term, metallurgical applications for rhenium probably have greater growth potential than do catalytic applications. Metallurgical research is underway into the use of rhenium-molybdenum alloys for satellites and rhenium-containing alloys for high temperature applications in aircraft engines. Iridium, gallium, germanium, indium, selenium, silicon, tin, tungsten and vanadium may all be replaced by rhenium under certain conditions.

Salt

M. PRUD'HOMME

SUMMARY

Canada produces rock salt from four underground mines and as by-product from two potash mines. Rock salt accounts for 66 per cent of total salt shipments. Brine is also produced in 11 plants for the manufacture of evaporated salt and chloralkalies.

In 1986, salt shipments in Canada rose by 10 per cent to 11 089 000 t. The average unit value for all kinds of salt increased by 2 per cent to $21.75 per t. In Nova Scotia, Domtar Chemicals Group, a division of Domtar Inc., completed a plant modernization to produce high-purity salt grades with substantial energy savings. Seleine Mines Inc. in Quebec has been seeking a partner or buyer for its salt operations and has undertaken development work for future production at the 160 m and 173 m levels. In Ontario, two methane gas explosions occurred late in 1986 at the underground operations of Domtar Inc. in Goderich; operations were halted for two weeks, and full production level should resume in early January 1987. In Western Canada, The Canadian Salt Company Limited installed two compaction systems to produce salt pellets for water conditioning in Belle Plaine and Lindberg.

On a nine-month basis, salt imports rose by 9 per cent to 1.74 million t, 64 per cent of which were imported from the United States, mainly in Ontario. Imports by British Columbia accounted for 41 per cent of total salt imports and were mainly from Mexico (52 per cent), Chile (23 per cent) and the United States (25 per cent). For the first nine months in 1986, exports rose by 19 per cent to 1.9 million t, compared to the same period in 1985. United States markets accounted for 99.7 per cent of total salt exports from Canada.

In early January 1986, the U.S. International Trade Commission found no material injury to the U.S. industry from dumping as alleged by The International Salt Company against Canadian rock salt exporters.

Canadian rock salt prices rose slightly in 1986, ranging between $23 and $42 per t for de-icing rock salt in bulk shipments, f.o.b. works. Demand for salt should maintain a slight growth in view of some rationalization and modernization in the Canadian chloralkali industry.

DOMESTIC PRODUCTION AND DEVELOPMENTS

In 1986, Canadian shipments of rock salt were estimated at 11 088 000 t, an increase of 9.9 per cent compared to 1985. Increases in shipments were mainly from Ontario and New Brunswick. The average unit value rose by 2 per cent to $21.79 per t.

Atlantic region. Salt deposits occur in isolated sub-basins of a large sedimentary basin that underlies the northern mainland of Nova Scotia and extends westward under the bordering areas of New Brunswick, northeastward under Cape Breton Island, Prince Edward Island, les Îles-de-la-Madeleine and southwestern Newfoundland. The salt beds occur within the Mississippian Windsor Group and are generally folded and faulted. The deposits appear to be steeply dipping tabular bodies, domes and brecciated structures of rock salt.

Salt production in the Atlantic Provinces is from an underground rock salt mine at Pugwash, Nova Scotia, an underground potash and salt mine at Sussex, New Brunswick and a brining operation near Nappan, Nova Scotia.

In New Brunswick, Potash Company of America (PCA) commenced to produce potash and by-product salt in 1983 at its underground mine near Sussex. Salt is extracted at a rate of 400 000 to 500 000 tpy and is sold mainly to the eastern United States. Reserves are estimated large enough to operate for at least 20 years. Salt is marketed for road de-icing and chemical plants. In late 1985, Rio Algom Limited of Toronto purchased all shares of PCA held by Ideal Basic Industries, Inc., to acquire a 87.8 per cent ownership of PCA. The salt

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grades were marketed under a sales contract to The International Salt Company of New York through Iroquois Salt Products Ltd., its Canadian subsidiary.

Denison-Potacan Potash Company produced small amounts of salt from its potash mine now under development at Salt Springs near Sussex. Salt grades are marketed locally.

In Nova Scotia, The Canadian Salt Company Limited operates an underground rock salt mine at Pugwash in Cumberland County, with a rated capacity of approximately 1 350 000 tpy. Most of the salt from this mine is used for snow and ice control. In the evaporated salt plant, saturated brine is fed to a quadruple effect vacuum pan, rated at 13 t/hr, where brine solution is evaporated to produce high quality salt crystals for use in the chemical and food industries. During 1986, the firm continued to work on some shipments facilities and considered different ways to improve accessibility to shipping docks and to increase the shipments tonnage through modification on maritime transportation modes. On land, a highway section from Pugwash to the Trans-Canada Highway has been upgraded, allowing larger truck shipments from Pugwash salt operation.

Domtar Chemicals Group has a brining operation at Nappan in Cumberland County. In October 1986, Domtar Inc. completed the plant modernization at Nappan. A new mechanical vapour recompression evaporating process system has been installed at a cost of $9.5 million, to produce high purity salt grades with substantial energy savings. Evaporated salt products will be used for table salt, fishery and water conditioning.

Quebec. A salt deposit located on the Archipelago of les Îles-de-la-Madeleine, in the Gulf of St. Lawrence, is part of the Mississippian Carboniferous Basin. Discovered in 1972, the Rocher-aux-Dauphins deposit is characterized by thick sequences of commercial salt, large sequences of rythmic salt and anhydrite cycles, abundance of low-grade potash horizons and some clay. The deposit is a typical piercement salt diapir generated by upward movements of the salt from the underlying anticlinal structure. It contains about 4 billion t of raw salt of which a quarter is above 97 per cent sodium chloride. The salt lies between 30 m and 75 m underneath the surface. The deposit dips about 55 degrees to the southwest. Reserves are 460 million t of which 34.2 per cent are mineable, grading an average of 94.5 per cent NaCl.

Seleine Mines Inc., a subsidiary of the Société québécoise d'exploration minière (SOQUEM), mines rock salt commercially since the spring of 1983. This underground operation has a production capacity of 1.23 million tpy, and reserves are sufficient for 20 years. All salt produced is for de-icing purposes and is shipped to mainland Quebec, Newfoundland and northeastern United States.

In 1986, the mine operated at around 85 per cent of rated capacity. Development work was undertaken and included installation of rock bolts, improvements of the crushing system and the construction of a second storage facility on surface. Levels at 160 m and 173 m have been developed for future mining when levels at 210 m and 223 m will be exhausted. In 1986, SOQUEM had to devalue the operations real estate assets at Seleine Mines Inc. in order to comply with the principle of company maintenance; in spite of increased profitability of the salt operations, SOQUEM had to write off nearly $76 million, which will make it possible to obtain a positive return on the long-term asset after amortization. During 1986, Seleine Mines Inc. has been seeking a partner or buyer in the framework of the privatization of state-owned societies from Quebec; however, the partnership project has been postponed for one year.

Ontario. Thick salt beds underlie much of southwestern Ontario, extending from Amherstburg northeastward to London and Kincardine, bordering on what is known geologically as the Michigan Basin. As many as six salt beds, occurring in the Upper Silurian Salina Formation at depths from 275 to 825 m, have been identified and traced from drilling records. Maximum bed thickness is 90 m, with aggregate thickness reaching as much as 215 m. The beds are relatively flat-lying and undisturbed, resulting in low-cost mining.

During 1986, those beds were worked through two rock salt mines, one at Goderich and one at Ojibway, and through brining operations at Goderich, Sarnia, Windsor and Amherstburg.

At Goderich, Domtar Chemicals Group operates an underground rock salt mine. New facilities are currently operating at full capacity; expansion has risen installed capacity up to 2.81 million t. During 1986, production tonnage rose due to resumed level of activities compared to 1985 when the operations were halted for three months due to a labor strike. In mid-November, an underground explosion happened in the salt mine due to a pocket of methane. The incident occurred in a restricted intersection where fallen rocks were reported. The activities resumed within one week, but the explosion area remained restricted. During mid-December, operations halted again, following a cave-in involving a second methane gas explosion. Ontario Ministry of Labor ordered the mine to be closed, but within two weeks, operations resumed at a reduced level but were to reach capacity by early January 1987. The explosion occurred in some development areas which were not crucial for the mine's operations. Domtar's salt is marketed mainly for ice control and it is sold mainly in eastern Canada, in the north central United States, and in regions accessible through the Mississippi River system. Evaporated salt is also produced at the Domtar brining operation also located near Goderich.

At Sarnia, Dow Chemical Canada Inc. produces brines from wells for the production of caustic soda and chlorine.

The Canadian Salt Company Limited produces both rock salt from the Ogibway underground mine and vacuum salt products from brine wells near Windsor. The total rated capacity is more than 2.25 million tpy. Rock salt is extracted from the Middle F - Unit at a depth of 297 m while brine is pumped from the B - Unit at depths of 427 m and 457 m.

In the vicinity of Amherstburg, General Chemical Inc., a division of General Chemical Canada Ltd., operates a brining operation for the manufacture of soda ash and by-product calcium chloride. This is the only remaining plant in North America that utilizes the Solvay process.

Prairie Provinces. Salt beds underlie a broad belt of the Prairie Provinces extending from the extreme southwestern corner of Manitoba, northwestward across Saskatchewan and into the north-central part of Alberta. Most of the salt deposits occur within the Prairie Evaporite Formation, which constitutes the upper part of the Middle Devonian Elk Point Group, with thinner beds of salt occurring in Upper Devonian rocks. Depths range from 180 m at Fort McMurray, Alberta, to 900 m in eastern Alberta, central Saskatchewan and southwestern Manitoba, and to 1 830 m around Edmonton, Alberta, and in southern Saskatchewan. Cumulative thicknesses reach a maximum of 400 m in east-central Alberta. The beds lie relatively flat and undisturbed. The same rock sequence contains a number of potash beds currently under exploitation in Saskatchewan.

In Saskatchewan, four companies produce salt from the Middle Devonian Prairies formation. International Minerals and Chemical Corporation (Canada) Limited (IMCC) supplies by-product rock salt from its potash operation at Esterhazy. Its salt is distributed locally for road de-icing by Kleysen Transport Company. Domtar Inc. operates a brining operation, near Unity, for the production of fine vacuum-pan salt and fusion salt. The Canadian Salt Company Limited at Belle Plaine uses by-product brine from an adjacent potash solution mining operation owned by PPG Canada Inc.'s division, Kalium Chemicals, to produce table salt. In 1986, The Canadian Salt Company Limited installed a $1 million compaction system to produce salt pellets for water conditioning. Saskatoon Chemicals, a division of Prince Albert Pulp Company Ltd., produces brines from wells near Saskatoon for the manufacture of caustic soda and chlorine, mainly used by pulp producers as a bleaching agent.

In Alberta, two producers operate brining operations: at Fort Saskatchewan near Edmonton, Dow Chemical Canada Inc. produces salt brine for the manufacture of chloralkali chemicals; and, at Lindberg, The Canadian Salt Company Limited produces fine vacuum pan salt. In 1986, the firm shut down the fused salt facilities and installed a compaction system to produce compressed salt for use in water conditioning.

In Alberta, salt deposits have been investigated for underground storage caverns where potential exists for further development.

British Columbia. There is no production of salt in this province where four companies operate six chloralkali plants: B.C. Chemicals Ltd. in Prince George, Tenneco Canada Inc. in North Vancouver, FMC of Canada Limited at Squamish and Canadian Occidental Petroleum Ltd. in North Vancouver, Squamish and Nanaimo. Raw materials are imported from Mexico, the United States and Chile. Late in 1986, FMC of Canada Limited sold its choralkali plant to Canadian Occidental Petroleum Ltd. for $25 million.

CONSUMPTION AND TRADE IN CANADA

Consumption. Consumption of all types of salt in 1985 has been estimated at 7 833 500 t, a 5 per cent increase over 1984. Snow and ice control accounted for 48 per cent of total consumption, followed by industrial chemicals (47 per cent).

Salt is to a large extent used as a chemical raw material accounting for 60 per cent of world consumption, followed by human diet with 17 per cent, road de-icing with 10 per cent; and the remainder 13 per cent to animal feed and water treatment. However, the pattern for consumption differs in North America where the chemical industry consumes about half of total production, followed by highway usage and the food industry.

The largest consumer of salt is the industrial chemicals industry, particularly for the manufacture of chloralkali, namely caustic soda (sodium hydroxyde), chlorine and soda ash (sodium carbonate). Salt for four caustic soda and chlorine plants in Canada is obtained from on-site brining and natural brines; others use mined rock salt or imported solar-evaporated salt. Chlorine is largely used by the plastics industry and as a bleaching agent for the manufacture of bleached pulp and newsprint. The principal uses for caustic soda are in the manufacture of organic and inorganic chemicals, pulp and paper, alumina and textiles. The glass industry is a major user of soda ash. Other industrial chemicals that require significant quantities of salt include sodium chlorate, sodium bicarbonate, sodium chlorite and sodium hypochlorite. The American Society for Testing and Materials' (ASTM) standard method E-534-75 covers the analytical procedures for chemical analysis of sodium chloride.

Consumption for snow and ice control varies from year to year, depending on weather conditions. For the past nine years, the average proportion for this purpose in Canada was about 45 per cent of total consumption, compared to 24 per cent for the United States and 14 per cent in western Europe. On a world basis, this application accounts for 10 per cent of total world salt consumption. For road de-icing, the ASTM provides standard specifications for sodium chloride: D632-72 (78). Rates of application are controlled by several factors such as precipitation, temperature, wind effects, traffic density and road conditions. Practices for such usage also include utilization of mixtures with calcium chloride or with sand and gravel as abrasive components.

Other consumption areas for salt include the food industry, animal diet, fishery industry and water treatment which all account for less than 10 per cent of total Canadian consumption. Slight growth in these markets should continue in the short term although there is some pressure to use less salt for health reasons in the food industry. By-products of solar salt have also been in use for years to control dust in industrial areas and on unsealed roads.

There are virtually no substitutes or alternatives for salt; however, calcium chloride, hydrochloric acid and potassium chloride can substitute for salt in de-icing, chemical processing or food flavouring, but at a higher cost.

Salt used for de-icing is posing major problems of corrosion and of environmental degradation. For many years, scientists have been investigating for suitable chemical treatment to protect concrete and steel against salt corrosive action, especially in parking garages, concrete highways and bridge infrastructures. In Canada, many cities are undertaking studies to evaluate the use of salt substitutes for de-icing usage.

The adverse effects of salt have been reduced through information seminars promoted by the Salt Institute in Washington, U.S.A. These seminars contribute to minimize salt damages on highways, streets, and infrastructures by promoting proper storage methods and controlled spreading.

Trade. The tonnage of salt imports in 1985 rose by 19 per cent to 1 255 518 t compared to 1984 levels; the average unit value increased by 15 per cent to $20.00 per t. Imports were mainly from the United States (64 per cent) and Mexico (25 per cent) to British Columbia (43 per cent), Ontario (36 per cent) and Quebec (16 per cent).

On a nine-month basis, 1986 imports rose by 9 per cent compared to the same period in 1985, while 1986 exports increased by 19 per cent in terms of tonnage and by

31 per cent in terms of value. 1986 exports were mainly from Ontario (79 per cent), Quebec (11 per cent) and New Brunswick (5 per cent).

WORLD PRODUCTION AND REVIEW

World production of salt in 1985 remained stable at 170 million t. Salt is produced in about 100 countries which are mostly self-sufficient for their consumption requirements. The United States is the leading producer of salt with 21 per cent of world production, followed by the U.S.S.R. (10 per cent), China (8.5 per cent), West Germany (6.2 per cent) and Canada (6.0 per cent).

United States. Total production of all types of salt in 1985 decreased by 3 per cent to 34.3 million t while reported sales remained at 39.5 million t. Apparent consumption in 1985 decreased slightly by 5 per cent to 40.6 million t; increased consumption for de-icing and food processing were offset by reduced demand in the chemical industry which has been under some rationalization since 1984. Salt exports increased by 10 per cent to 820 000 t, 98 per cent of which were shipped to Canada. Imports of salt in 1985 decreased by 18 per cent to 5.6 million t, mainly from Canada (43 per cent), Mexico (20 per cent) and the Bahamas (15 per cent).

The average unit value of bulk rock salt rose 14 per cent to $US 14.31 per short ton. Salt in the United States is mainly used for the production of chloralkali (47 per cent), ice control (27 per cent), general industrial products (5 per cent), agriculture (3 per cent), and food processing (3 per cent). In 1985, 36 plants were producing brine, 34 plants for evaporated salt and 15 mines for rock salt.

Diamond Crystal Salt Company shelved the announced joint venture agreement with Amax Inc. Solar salt would have been produced by a 300 000 tpy processing plant at Timpie Point, Utah. The announcement followed the flooding of the solar evaporation ponds due to a major break in a protective dyke on Great Salt Lake. Negotiations may resume after the assessment of the damage.

Diamond Crystal Salt Company announced the closure of its salt operations at Jefferson Island, Louisiana, with the loss of about 70 jobs. The mine was flooded in 1980 as a result of an oil-rig drilling accident. In 1983, Diamond Crystal Salt Company received a settlement of $18 million from Texaco and the contracted drilling company. Diamond Crystal Salt Company has also acquired the salt division of Hardy Salt Co. The sale includes evaporated salt plants in Manistee, Michigan, and Williston, North Dakota, and distribution centers in Minnesota, Missouri, Ohio, Utah and Wisconsin.

Pennwalt Corporation announced plans to close its salt brine operation at Wyandotte in Michigan by year-end of 1986. The plant was established in 1850 and was producing chlorine and caustic soda; the closure followed the decision of a major restructure of the company.

China. Three new salt plants have been inaugurated in the province of Quinghai. The capacity of processing crude salt is estimated at 400 000 tpy for each plant. Current production in this province amounted to 650 000 tpy.

Poland. Mogilno salt mine started to operate in the Kujawy region. Salt is shipped to the chemical industry at Janikowo, Matwy, Bydgoszcz and Wloclawek.

Thailand. The Thai Asahi Group has undertaken a feasibility study for a 100 000 tpy rock salt operation in Phimai with a planned investment of $US 6.3 million. Technical assistance is supplied by Kavernen Bau und Betriebs of West Germany.

INTERNATIONAL TRADE

Salt is a widespread, low value and bulk commodity. It is relatively cheap to extract and transportation represents a significant proportion of the total delivered price of salt. As a result, international trade in salt is small relative to world production, i.e., 27 million t which is about 15 per cent of total world production. Major international routes consist of cross-border trade and trade within geographical areas. The cross-border trade between Canada and the United States account for 14 per cent of world total, between Mexico and the United States for 11 per cent. Trade within western Europe which involves the Scandinavian countries, the Netherlands, France, Benelux, Poland, Italy, East and West Germany accounts for 37 per cent of world total. Trade within the Pacific area accounts for about 38 per cent of world total.

In the Pacific Rim, Japan is the major importing country with 6.8 million t of imported salt, mainly from Australia (48 per cent), Mexico (42 per cent) and China (10 per cent). In 1985, Australia exported 5.4 million t of salt, 61 per cent of which was exported to Japan and 10 per cent to the Republic of Korea. Mexico exported 5.9 million t of salt of which shipments to Japan accounted for 57 per cent. Japan imports of salt rose by 6 per cent in 1985 to 6.8 million t due to increasing shipments from Australia which contributed to 75 per cent of the increase.

Within North America, Mexican salt exports to the United States accounted for 35 per cent of total salt exports, and for 7 per cent to Canada. United States is the major importer of Canadian salt, accounting for 43 per cent of total salt imports while exports to the United States accounted for 99 per cent of total Canadian salt exports.

A final antidumping ruling in the United States, related to rock salt imported from Canada, was made by the U.S. International Trade Commission which concluded in early January 1986 that no material injury had affected the U.S. salt industry.

PRICE

Salt is not a standard commodity and its price ranges depend on such factors as production methods, purity, scale of operations and transportation costs.

In 1986, Canadian rock salt prices, bulk, f.o.b. works, for de-icing purposes range between $22-42 per t. Fine evaporated salt prices varied between $80-105 per t while fishery grade salt was sold for $95 to $100 per t.

OUTLOOK

Canada is de facto self-sufficient in salt since our exports surpass our imports. Eastern Canadian requirements of rock salt are served locally while imports serve western needs for chloralkali plants in British Columbia. Current capacity should be sufficient to meet any forecast increase in demand for the next decade.

The industrial chemicals industry is likely the sector of consumption which will see strong growth in the decade. The major end-use of salt is for the production of chloralkali, namely caustic soda, chlorine and sodium carbonate.

Caustic soda markets are affected by its consumption in the aluminum industry, by the substitution from soda ash in the glass industry, and by fluctuations of newsprint and linerboard production in the pulp and paper industry. However, the greatest impact is coproduction with chlorine. The rationalization that has started in the United States since 1984 will continue and spread to the Canadian chloralkali industry in 1987. During 1986, plants operated at a high-capacity rate. This level should be maintained in 1987 due to rationalization within the chloralkali industry and strong demand for plastic resins and for paper. Prices for chlorine should increase by 15 per cent while prices for caustic soda should remain unchanged.

Chlorine demand is dependent on polyvinyl chloride (PVC) usage in the construction and automobile sectors (41 per cent of total consumption), on the pulp and paper industry for usage as a bleaching agent (39 per cent) and on the chemicals industry. Chlorine demand is expected to continue to grow at about 3 per cent per year up to 1995. Availability of chlorine will be adequate in Canada until 1990 since current capacity, near 1 525 000 tpy, exceeds demand.

The usage of salt for de-icing is tied to the North American market. In the long term, controlled application rates, environmental considerations, substitutes and urban access optimization will limit salt consumption on a t/km basis but a slow growth rate of between 1 and 2 per cent is still forecast, due to the growth of the road network.

In the food industry, salt is a major supplement and a well-used preservative. Its demand is linked to population growth and should increase despite the current public concern, in some countries, related to the high sodium diet. An annual average growth rate of 1.2 per cent is forecast for the next two decades by the U.S. Bureau of Mines.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
CANADA					
92501-1	Common salt (including rock salt)	free	free	5¢/100 lb	free
92501-2	Salt for use of the sea or gulf fisheries	free	free	free	free
92501-3	Table salt made by the admixture of other ingredients when containing not less than 90 per cent of pure salt	4.1	4.1	15	2.5
92501-4	Salt liquors and sea water	free	free	free	free

MFN Reductions under GATT (effective January 1 of year given)		1986	1987
		(%)	
92501-3		4.1	4.0
UNITED STATES, Customs Tariffs (MFN)			
420.92	Salt in brine	3.9	3.7
420.94	Salt in bulk	0.4	free
420.96	Salt, other	remains free	

Sources: The Customs Tariff, 1986, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated (1986), USITC Publication 1775; U.S. Federal Register.

TABLE 1. CANADA, SALT PRODUCTION AND TRADE, 1984-86

	1984		1985		1986P	
	(tonnes)	($)	(tonnes)	value $000	(tonnes)	value $000
Shipments						
By type						
Mined rock salt	7 030 664	125,682,259	6 608 739	120,514,399	..	..
Fine vacuum salt	754 675	71,219,195	805 209	79,702,911	..	..
Salt content of brines used or shipped	2 450 060	13,289,181	2 670 749	15,144,460	..	..
Total	10 235 399	210,190,635	10 084 697	215,361,770	11 088 000	241,611,000
By province						
Nova Scotia	..	..	..	..	..	..
New Brunswick	..	..	..	..	..	..
Quebec	..	..	..	..	..	..
Ontario	6 412 414	131,720,179	5 828 762	125,233,440	6 708 541	145,104,000
Saskatchewan	402 217	20,362,349	437 410	24,436,993	442 404	25,396,000
Alberta	1 263 841	15,426,431	1 403 500	17,995,013	1 391 400	22,203,000
Total	10 235 399	210,190,635	10 084 697	215,361,770	11 088 524	241,611,000
Imports						
Salt, wet in bulk						
Mexico	271 957	2,839,000	309 122	3,200	288 826	3,779
United States	183 744	2,705,000	232 568	3,651	18 843	293
Total	455 701	5,544,000	541 690	6,851	307 669	4,072
Salt, domestic						
United States	10 031	1,319,000	10 891	2,000	10 925	1,970
Switzerland	40	30,000	83	55	220	37
Netherlands	1	..	2	10	53	26
Other countries	44	8,000	78	12	150	33
Total	10 116	1,358,000	11 054	2,077	11 350	2,066
Salt, nes						
United States	505 931	10,417,000	554 926	14,107	832 618	17,695
Spain	16 401	261,000	35 660	624,000	25 809	470
Chile	24 859	252,000	59 572	616,000	109 515	1,161
Bahamas	20 649	277,000	51 742	828	14 244	246
Other countries	19 560	255,000	874	40	27 084	388
Total	587 400	11,482,000	702 774	16,215,000	1 009 270	19,960
Salt and brine by province of clearance						
Newfoundland	18 389	380,000	39 144	737	39 621	739
Nova Scotia	19 117	249,000	17 571	271	3 506	59
New Brunswick	46	24,000	1	..	3 872	74
Quebec	98 094	1,761,000	196 587	3,290	304 471	4,979
Ontario	454 757	8,133,000	448 330	11,190	407 217	9,443
Manitoba	3 059	211,000	4 959	331	3 840	287
Saskatchewan	3 607	341,000	5 268	523	6 959	768
Alberta	8 534	630,000	8 513	681	7 220	549
British Columbia	447 611	6,735,000	535 145	8,120	551 592	9,200
Total	1 053 217	18,304,000	1 255 518	25,143	1 328 298	26,098
Exports						
Salt and brine						
United States	2 524 114	29,023,000	2 257 550	28,566	2 494 976	35,788
Leeward-Windward Islands	1 452	144,000	1 500	237	1 549	162
Guyana	1 001	166,000	1 600	150	0	0
Other countries	3 471	477,000	2 426	318	5 988	574
Total	2 530 038	29,810,000	2 263 076	29,272	2 502 513	36,484

Sources: Statistics Canada; Energy, Mines and Resources Canada.
P Preliminary; .. Not available; nes - Not elsewhere specified.
Note: Totals may not add up due to rounding.

TABLE 2. CANADA, SUMMARY OF SALT PRODUCING AND BRINING OPERATIONS, 1984 AND 1985

Company	Location	Initial Production	Production[1] 1985P (1984)	Employment 1985P (1984)	Remarks
			(000 tonnes)		
Nova Scotia					
The Canadian Salt Company Limited	Pugwash	1959	684.0 (625.4)	166 (185)	Rock salt mining to a depth of 253 m.
	Pugwash	1962	82.3 (81.4)		Dissolving rock salt fines for vacuum pan evaporation.
Domtar Inc.	Nappan	1947	58.0 (57.8)	81 (74)	Brining for vacuum pan evaporation.
New Brunswick					
Potash Company of America	Sussex	1980	475.5 (418.1)	32[2] (25)	By-product rock salt from potash mine for use in snow and ice control.
Quebec					
Seleine Mines Inc.	Îles-de-la-Madeleine	1982	997.0 (923.5)	206 (206)	Rock salt mining to a depth of up to 275 m.
Ontario					
General Chemical Canada Ltd.	Amherstburg	1919	618.1 (620.1)	8[2] (8)	Brining to produce soda ash.
The Canadian Salt Company Limited	Ojibway	1955	2 408.0 (2 215.9)	219 (208)	Rock salt mining at a depth of 300 m.
	Windsor	1892	140.0 (132.0)	145 (137)	Brining, vacuum pan evaporation and fusion.
Domtar Inc.	Goderich	1959	1 838.0 (2 700.5)	338 (355)	Rock salt mining at a depth of 536 m.
	Goderich	1880	98.0 (103.8)	73 (71)	Brining for vacuum pan evaporation.
Dow Chemical Canada Inc.	Sarnia	1950	789.0 (758.0)	4[2] (5)	Brining to produce caustic soda and chlorine.
Prairie Provinces					
International Minerals & Chemical Corporation (Canada) Limited	Esterhazy, Sask.	1962	91.9 (108.6)	3 (3)	By-product rock salt from potash mine for use in snow and ice control.
The Canadian Salt Company Limited	Belle Plaine, Sask.	1969	120.9 (100.4)	24 (25)	Producing fine salt from by-product brine from potash operation.
Domtar Inc.	Unity, Sask.	1949	163.0 (148.1)	88 (87)	Brining, vacuum pan evaporation and fusion.
Saskatoon Chemicals	Saskatoon, Sask.	1968	55.1 (52.0)	5 (5)	Brining to produce caustic soda and chlorine.
The Canadian Salt Company Limited	Lindbergh, Alta.	1968	138.3 (125.9)	77 (79)	Brining, vacuum pan evaporation and fusion.
Dow Chemical Canada Inc.	Fort Sask., Alta.	1968	1 241.9 (1 137.9)	3[2] (3)	Brining to produce caustic soda and chlorine.
			9 999.0 (10 309.4)	1 472 (1 476)	

Compiled by Mineral Policy Sector, Energy, Mines and Resources Canada, 1986.
[1] Shipments. [2] Employment part of chemical complex.
P Preliminary.

TABLE 3. CANADA, SALT SHIPMENTS AND TRADE, 1979-85

	Producers' Shipments					
	Mined Rock	Fine Vacuum	In Brine and Recovered in Chemical Operations	Total	Imports	Exports
			(tonnes)			
1979	4 934 574	735 460	1 645 914	7 315 948	1 276 179	1 822 120
1980	4 507 416	781 428	2 134 010	7 422 854	1 151 203	1 637 601
1981	4 371 314	764 037	2 107 243	7 242 594	1 254 992	1 507 710
1982	5 223 073	773 086	1 944 172	7 940 331	1 526 879	1 721 893
1983	5 846 994	714 464	2 040 925	8 602 383	814 250	1 914 629
1984	7 030 664	754 675	2 450 060	10 235 399	1 053 217	2 530 038
1985	6 608 739	805 209	2 670 749	10 084 697	1 255 518	2 263 076
1986P	..	..	..	11 088 000	1 328 298	2 502 513

Sources: Statistics Canada; Energy, Mines and Resources Canada.
P Preliminary; .. Not available.

TABLE 4. CANADA, AVAILABLE DATA ON SALT CONSUMPTION, 1982-85

	1982	1983	1984p	1985e
	(tonnes)			
Snow and ice control[1]	3 088 315	2 712 088	3 560 809	3 796 200
Industrial chemicals[2]	2 966 218	3 226 558	3 586 487	3 695 000
Fishing industry	83 000	55 000	58 000	66 000
Food processing				
Fruit and vegetable processing	18 008	14 887	18 269	19 000
Bakeries	13 746	12 686	11 947	15 000
Fish products	33 582	28 281	24 071	33 000
Dairy products	10 447	10 130	10 484	12 000
Biscuits	2 082	1 981	2 040	2 000
Miscellaneous food preparation	22 680	21 863	24 787	26 000
Grain mills[3]	63 899	64 289	64 254	73 000
Slaughtering and meat processors	37 347	32 889	29 557	33 000
Pulp and paper mills	30 009r	30 205	30 048	34 000
Leather tanneries	7 708	5 137	7 948	8 000
Miscellaneous textiles	2 871	4 287	3 758	4 000
Breweries	279	512	333	300
Other manufacturing industries	7 923	13 857	11 287	12 000
Total	6 388 114r	6 243 650	7 444 079	7 833 500

Sources: Statistics Canada; Salt Institute.

[1] Fiscal year ending June 30. [2] Includes rock salt, fine vacuum salt and salt contained in brine. [3] Includes feed and farm stock salt in block and base forms.

e Estimated by Energy, Mines and Resources Canada; p Preliminary; r Revised.

TABLE 5. CHLORALKALI PLANTS IN CANADA, 1986

Company	Location	Parent Company	Plant Location	Type of Cells	Products	Capacity (tonnes)	Remarks
B.C. Chemicals Ltd.	Prince George, British Columbia	B.C. Chemicals Ltd., Prince George, B.C.	Prince George, British Columbia	-	sodium chlorate	33 000	Captive production.
BCM Technologies Inc.	Amherstburg, Ontario	BCM Technologies Inc., Amherstburg, Ontario	Amherstburg, Ontario	-	sodium chlorate	45 000	
Canadian Occidental Petroleum Ltd.	Calgary, Alberta	Occidental Petroleum Corporation, Los Angeles, CA U.S.A.	Brandon, Manitoba	-	sodium chlorate	11 000	Expansion planned for 1987 to 17 500 t.
			Nanaimo, British Columbia	- diaphragm	sodium chlorate caustic soda chlorine	8 000 31 000 28 000	
			North Vancouver, British Columbia	diaphragm	caustic soda chlorine	155 000 141 000	
			Squamish, British Columbia	-	sodium chlorate	11 000	
Canso Chemicals Limited	New Glasgow, Nova Scotia	C-I-L Inc., North York, Ontario	Abercrombie Point, Nova Scotia	mercury	caustic soda chlorine	20 000 18 000	
C-I-L Inc.	Willowdale, Ontario	C-I-L Inc., North York, Ontario	Becancour, Quebec	diaphragm	caustic soda chlorine	325 000 295 000	
			Cornwall, Ontario	mercury	caustic soda chlorine	38 500 35 000	
			Dalhousie, New Brunswick	mercury	caustic soda chlorine	31 000 28 000	
Dow Chemical Canada Inc.	Sarnia, Ontario	Dow Chemicals Canada Inc., Sarnia, Ont.	Fort Saskatchewan, Alberta	diaphragm	caustic soda	524 000	Expansion for capacity of production by 33.5 per cent shelved to 1987.
			Sarnia, Ontario	diaphragm	caustic soda chlorine	350 000 318 000	

ERCO Industries of Canada Limited	Islington, Ontario	Albright & Wilson Inc., London, England	Buckingham, Quebec	-	sodium chlorate	88 000	Second phase expansion of 44 000 t planned for 1987, phasing out 55 000 t capacity from old graphite cells plant.
			North Vancouver, British Columbia	-	sodium chlorate	54 000	
			Thunder Bay, Ontario	-	sodium chlorate	46 000	
FMC of Canada Limited	Squamish, British Columbia	FMC Corporation Chicago, Ill., U.S.A.	Squamish, British Columbia	mercury	caustic soda chlorine	75 000 68 000	Sold to Canadian Occidental Petroleum Ltd. in December 1986.
Great Lakes Forest Products Limited	Thunder Bay, Ontario	Great Lakes Forest Products Limited Thunder Bay, Ontario	Dryden, Ontario	membrane	caustic soda chlorine	16 000 14 500	
PPG Canada Inc. Industrial Chemical Division	Toronto, Ontario	PPG Industries Inc. Pittsburg, Penn., U.S.A.	Beauharnois, Quebec	-	sodium chlorate	80 000	1985 capacity.
				mercury	caustic soda chlorine	67 000 61 000	
QueNord Inc.	Magog, Quebec	KemaNobel AB, Sweden	Magog, Quebec	-	sodium chlorate	90 000	Increased capacity by 1986, with high efficiency cells.
St. Anne-Nackawic Pulp & Paper Co. Ltd	Nackawic, New Brunswick	Parsons and Whitemore	Nackawic, New Brunswick	-	sodium chlorate	9 000	Captive production.
				membrane	caustic soda chlorine	10 000 9 000	
Saskatoon Chemicals	Saskatoon, Saskatchewan	Prince Albert Pulp Company Ltd. Prince Albert, Saskatchewan	Saskatoon, Saskatchewan	-	sodium chlorate	25 000	
				membrane	caustic soda chlorine	36 000 33 000	
Alby-Olin Chlorate Co.	Valleyfield, Quebec	Alby, Sweden Olin Corp., U.S.A.	Valleyfield, Quebec	-	sodium chlorate	50 000	Operation started in September 1986.

Sources: Energy, Mines and Resources Canada, Mineral Policy Sector; Department of Regional Industrial Expansion (Ottawa), Chemicals Directorate; ministère de l'Industrie, du Commerce et du Tourisme du Québec.

TABLE 6. WORLD SALT PRODUCTION, 1981-85

Countries	1981	1982	1983^r	1984P	1985^e
			(000 tonnes)		
United States	35 025	34 355	31 385	35 605	35 840
U.S.S.R.^{e}	15 195	15 420	16 200	16 525	16 960
China^e	18 315	15 965	16 125	16 280	14 420
West Germany	12 535	11 520	10 400	11 160	10 520
Canada	7 240	8 070	8 615	10 235	10 080
France	6 635	6 650	6 950	7 000	7 840
India	8 920	9 980	7 010	7 730	7 530
United Kingdom	6 720	6 895	6 310	7 125	7 250
Mexico	7 950	7 980	5 700	6 155	5 980
Australia	5 300	5 625	5 170	4 990	4 990
Poland	4 270	4 260	3 625	4 710	4 850
Romania	5 030	4 750	4 590	4 535	4 540
Italy	4 565	4 530	4 540	4 250	4 170
Other	32 620	32 700	32 500	34 850	35 300
Total	170 320	168 700	159 120	171 150	170 270

Source: U.S. Bureau of Mines.
P Preliminary; ^{e} Estimated; ^{r} Revised.

Silica

MICHEL A. BOUCHER

SUMMARY

Preliminary figures indicate that in 1986 silica production in Canada fell 8 per cent in terms of tonnage while the total value of production increased 0.7 per cent. Production increased in Quebec and New Brunswick, decreased in Ontario and Saskatchewan, and remained about the same in the rest of the country.

With the exception of the flat glass and fiberglass markets which are related to the construction industry, all the other markets for silica were either stagnant or declining in 1986.

The consumption of silica by the glass container industry which is the largest consumer of high quality silica continued to be affected negatively by the use of recycled glass waste. Competition from aluminum, paper and plastics also continued to erode markets traditionally belonging to glass containers.

CANADIAN SCENE

Newfoundland

All silica production from Dunville Mining Company Limited, a subsidiary of Tenneco Canada Inc. is captive to Tenneco, a producer of elemental phosphorus, where silica is used as a flux. The quartzite quarry at Villa Marie operates from May to December and produces silica grading close to 95 per cent SiO_2. The ore is shipped to Tenneco's Long Harbour phosphorus plant.

Nova Scotia

Nova Scotia Sand and Gravel Limited produces a high purity silica from sand deposits, for a variety of uses such as sandblasting, glass, foundry sand, and frac sand. The mine is located near Shubenacadie.

New Brunswick

Chaleur Silica Ltd. produces silica for use as a flux in Brunswick Mining and Smelting Corporation Limited's Belledune lead smelter, for cement plants, and as sandblasting material.

Quebec

Falconbridge Limited is the largest producer (in terms of volume and value of production) of silica east of Ontario with a total production capacity of some 500 000 tpy. Silica is mined from a quartzite deposit at Saint Donat and from a sandstone deposit at Saint Canut. Silica from Saint Donat is refined at the Saint Canut plant near Montreal.

Most silica produced by Falconbridge originates from Saint Canut where the ore is crushed, screened and beneficiated by attrition scrubbing, flotation and magnetic separation. The major markets for Falconbridge products are the glass, fiberglass and silicon carbide industries.

Baskatong Quartz Inc. produces high-purity silica from a quartzite deposit north of Saint Urbain. The silica is used mainly by SKW Canada Inc. for the production of ferrosilicon and silicon metal. Baskatong also produces high-purity silica from a quartzite deposit located at Lac Bouchette. The silica is sold to the ferroalloy industry.

Les Entreprises Loma Ltée of Beauport crushes and classifies the fines produced by SKW Canada Inc. The silica is sold to the silicon carbide and sandblast industries. The company plans to modernize its operation in the near future and an expansion is also under study.

Armand Sicotte & Sons Limited mines Potsdam sandstone at Sainte Clothilde, south of Montreal. Lump silica is used for the production of ferrosilicon, phosphorus, and in the cement industry.

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La Compagnie Bon Sable Ltée mines silica sand and gravel at St. Joseph-du-Lac and at Ormstown. The material is used mainly for sandblasting but also for fiberglass and foundries.

Ontario

Falconbridge Limited is also the largest producer (in terms of volume and value of production) of silica west of Quebec, with a reported total capacity of about 500 000 tpy, about the same as its Quebec operation. Lump quartzite from Badgeley Island, north of Georgian Bay is shipped by lake boat to Canadian destinations for the manufacture of ferrosilicon. The finer material produced by crushing, is shipped to Midland, south of Georgian Bay where it is further processed to a glass-grade silica sand, and silica flour for ceramic and other uses.

Manitoba

Marine Transport Limited of Selkirk, produces high-purity silica sand from a quarry on Black Island on Lake Winnipeg some 130 km north of Selkirk. The silica sand, mined from a poorly consolidated white sandstone, is well rounded and suitable for use in foundries, glass and fiberglass. The ore is washed, screened and dewatered at a plant on the island, and is then shipped by barge to a processing plant at Selkirk on the Red River.

Inco Limited produces a low-grade silica from an impure quartzite from the Manasan quarry for its Thompson smelter and converter. Production varies from year to year depending on nickel production.

Saskatchewan

Hudson Bay Mining and Smelting Co., Limited produces smelter flux from two pits in northern Saskatchewan.

Red Deer Silica Inc. plans to start production of silica in mid-1987 from a sand deposit located near the town of Hudson Bay. The deposit contains 14 million t proven reserves of silica grading 97 to 99 per cent SiO_2 with minor amounts of alumina and iron oxide. The company intends to produce about 200 000 tpy of silica for the foundries, sandblasting, filtration, flux and glass industries.

Alberta

Sil Silica a division of Strathcona Resource Industries Ltd., produces silica sand from local sand dunes in the Bruderheim area. Silica is sold mainly as fiberglass and sandblasting material. It is also sold as foundry sand, filtration sand, frac sand and as railway traction sand. Sil Silica has shown steady growth even during depressed economic conditions.

British Columbia

Mountain Minerals Co. Ltd., which mines a high-purity, friable sandstone deposit near Golden, has upgraded its processing plant. Rock is crushed, screened, washed, dried and separated into several sizes. These different sizes are sold for glass sand, sandblasting sand, foundry sand, filter media sand, golf course sand and fine sand. The company is conducting on-going research and development aimed at producing a variety of new products.

TRADE

Most silica sand imported into Canada comes from loosely consolidated and easily processed sandstone or lake sand deposits located near the Great Lakes region of the United States in Illinois, Wisconsin, Michigan and Indiana. The imported silica sand is used mainly by iron and steel foundries and by the glass industry of Ontario and Quebec.

OUTLOOK

Little improvement is expected in 1987 in Canada in the container glass, foundry and sandblast industries. The flat glass and fiberglass industries should fare better as construction activity improves. In the long term, competition from U.S. producers of silica for glass and foundry sand will remain strong in Ontario and Quebec because of the proximity of these provinces to the low-cost producers of the United States Great Lakes region. Also due to the downsizing of passenger cars and recycling of silica sand at foundries, only small growth can be expected in the foundry sand industry in Canada. Competition from substitutes for glass containers such as paper, plastics and aluminum will remain strong across Canada.

Productivity improvements as well as efforts in the field of packaging will be necessary in order to prevent a further erosion of the glass containers markets.

However, if energy prices remain relatively low over a long period of time, more competition can be expected from plastics as the cost of resins used to manufacture plastics will decrease.

Eventually higher purity and higher value silica could be produced in Canada such as optical quartz and solar grade silica. Also, because electricity is not expensive in parts of Canada, **cultured quartz, fused quartz, refined silicon carbide, and polycrystalline silicon** could be manufactured. None of these products are yet manufactured in Canada.

PRICES

There are no published prices for silica by end use. However, it was reported that due to poor market conditions, the price paid for silica used by glass containers manufacturers in Ontario was lower than in 1981 by approximately 8 per cent.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			%		
CANADA					
29500-1	Ganister and sand	free	free	free	free
29700-1	Silex or crystallized quarters, ground or unground	free	free	free	free
UNITED STATES					
513.14	Sand, other		free		
514.91	Quartzite, whether or not manufactured		free		
523.11	Silica, not specially provided for		free		
				1986	1987
				¢ per long ton	
513.11	Sand containing 95 per cent or more silica and not more than 0.6 per cent oxide of iron			3	free

Sources: The Customs Tariff, 1986, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated (1986). USITC Publication 1775: U.S. Federal Register Vol. 44, No. 241.

TABLE 1. CANADA, SILICA PRODUCTION (SHIPMENTS) AND TRADE, 1984-86

	1984		1985		1986P	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Production (shipments), quartz and silica sand						
By province						
Quebec	763 515	14,703	741 617	15,428	821 000	15,914
Ontario	1 147 602	12,125	1 126 358	11,499	831 863	11,167
Alberta	x	3,163	x	4,432	x	4,500
Manitoba	x	3,038	x	2,808	x	2,978
Nova Scotia	x	x	x	x	x	x
New Brunswick	x	x	x	x	x	x
Saskatchewan	127 578	x	147 916	x	122 170	x
Newfoundland	x	x	x	x	x	x
British Columbia	x	1,730	x	2,180	x	1,912
Total	2 658 932	40,845	2 668 650	42,536	2 436 513	42,834
Imports[1]					**(Jan.-Sept. 1986)**	
Silica sand						
United States	1 076 068	19,403	983 246	22,691	725 976	14,698
West Germany	6	1	8	1	2	x
Other countries	9	4	17	5	-	14,698
Total	1 076 083	19,408	983 271	22,697	725 978	14,698
Silex and crystallized quartz						
United States	437	372	312	289	249	213
Japan	19	26	12	18	30	44
Other countries	38	9	17	19	1	2
Total	494	407	341	326	280	259
Silica (incl. silica gel)						
United States	7 722	13,256	7 207	12,493	6 520	10,067
West Germany	1 024	2,567	1 033	2,479	785	2,284
Other countries	655	1,541	723	1,366	410	822
Total	9 401	17,364	8 963	16,338	7 715	13,173
Exports						
Quartzite						
United States	116 265	931	112 762	1,136	78 823	1,086
Other countries	18	1	-	-	-	-
Total	116 283	932	112 762	1,136	78 823	1,086

Source: Statistics Canada; Energy, Mines and Resources Canada.
P Preliminary; - Nil; x Confidential.
[1] Includes sand for use in foundries and glass manufacturing, ground and flour sand, volatized and silica flue dust.

TABLE 2. IMPORTS OF SILICA SAND, (FROM UNITED STATES) BY PROVINCE BY USE 1985

Use		Newfoundland	Nova Scotia	Prince Edward Island	New Brunswick	Quebec	Ontario	Manitoba	Saskatchewan	Alberta	British Columbia	Total
Foundry	tonnes	-	1 305	-	201	32 571	397 855	836	854	1 573	27 815	463 009
	$000	-	20	-	5	943	4,912	111	41	48	1,410	7,490
Glass manufacturing	tonnes	-	-	-	-	14 966	210 486	-	-	-	27 365	252 817
	$000	-	-	-	-	174	2,535	-	-	-	798	3,507

Source: Statistics Canada
- Nil.

TABLE 3. CANADA, SILICA PRODUCTION AND TRADE, 1970, 1975, AND 1979-85

Year	Production	Imports		Exports	Consumption
	Quartz and Silica Sand	Silica Sand	Silex or Crystallized Quartz	Quartzite	Quartz and Silica Sand
		(tonnes)			
1970	2 937 498	1 176 199	186	58 917	3 979 305
1975	2 491 715	1 044 160	1 550	39 977	3 510 818
1979	2 368 497	1 651 890	1 259	60 823	3 611 815
1980	2 252 000	1 200 237	281	63 166	3 326 956
1981	2 238 000	1 142 880	251	119 347	3 079 225
1982	1 797 000	788 768	241	65 333	2 400 549r
1983	2 303 451	982 662	271	103 960	2 792 580
1984	2 658 932	1 076 082	494	116 283	3 227 477
1985	2 668 650	983 271	341	112 762	3 160 598

Sources: Statistics Canada; Energy, Mines and Resources Canada.
r Revised.

TABLE 4. FLAT GLASS AND CONTAINER GLASS MANUFACTURING PLANTS IN CANADA

Company	Plant Location	Type of Glass
PPG Canada Inc.	Owen Sound, Ontario	Flat
Ford Glass Limited	Scarborough, Ontario	Flat
Domglas Inc.	Scoudouc, N.B.	Containers
	Montreal, Quebec	"
	Brampton, Ontario	"
	Hamilton, Ontario	"
	Redcliff, Alberta	"
Consumers Packaging Inc.	Montreal, Quebec	Containers
	Candiac, Quebec	"
	Toronto, Ontario	"
	Milton, Ontario	"
	Lavington, B.C.	"

TABLE 5. CANADA, REPORTED CONSUMPTION OF SILICA, BY INDUSTRIES, 1984-85

	1984	1985P
	(tonnes)	
Smelter flux	961 711	1 070 409
Glass manufacture (including glass, fibre and glass fibre wool)	871 338	834 579
Foundries	611 863	547 888
Chemicals	217 063	198 495
Cement and concrete products	208 751	178 531
Heavy clay products	157 875	165 645
Artifical abrasives	141 117	105 872
Other products[1]	57 759	59 179
	3 227 477	3 160 598

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[1] Includes asbestos products, ceramic products, cleansers, fertilizer, stock and poultry feed, frits and enamels, gypsum products, metallurgical, paint and varnish, paper and paper products, refractory brick and mixes, roofing, and toilet preparations.
P Preliminary.

Silicon, Ferrosilicon, Silicon Carbide and Fused Alumina

D.R. PHILLIPS

SUMMARY

The Canadian silicon (ferrosilicon, silicon metal and silicon carbide) and fused alumina (aluminum oxide) industries operated at near capacity in 1985 and 1986. Some reduction in production can be anticipated in 1987 as the outlook for silicon consumption is about 5 per cent less than in 1986 due to a decrease in activity in the iron and steel industry. However, the production of fused alumina in 1987 is forecasted to remain at the same level as that of 1986. In general, the Canadian silicon industry will remain competitive due to the continued low cost of hydroelectric power and a favourable exchange rate for the Canadian dollar.

Silicon is the second most abundant element in the earth's crust. It is derived from quartz which accounts for about 25 per cent of the earth's crust. Although high purity silica resources are abundant throughout the world, the production of ferrosilicon, silicon metal, silicon carbide, silicon nitride and sialons is located within close proximity to low-cost and reliable sources of electric energy, due to the high electric power consumption required in making these products. Consequently, Canadian plants producing silicon products and aluminum oxide are located in Quebec and southern Ontario, where there is an abundance of electric power.

CANADA

Canadian ferrosilicon and silicon metal plants are nearly all located in Quebec where large supplies of competitively priced hydroelectric power and raw materials are available. There were three Quebec producers of ferrosilicon in 1985 and 1986, one of which produced silicon metal. By-product ferrosilicon was also produced at Thorold, Ontario in the manufacture of fused alumina abrasives.

Ferrosilicon is offered for sale in several grades, expressed in terms of per cent contained silicon. The more common grades of 50, 75 and 85 per cent are produced for consumption by the iron and steel industry. By-product ferrosilicon usually grades below 17 per cent; it is most commonly used in the flotation circuit of mineral processing operations and in the manufacture of specialty cements.

Following Elkem Metal Canada Inc.'s acquisition of Union Carbide Corporation's ferroalloy facilities in 1984, the company established new warehousing facilities in Hamilton. The new facility opened in September 1985 and is Elkem's major distribution center for ferroalloys in Canada. Elkem produced ferrosilicon at its plant in Chicoutimi in 1985 and 1986.

SKW Canada Inc. was in the process of modernizing its plant at Bécancour, Quebec. The program is on schedule and is expected to be completed in 1987. SKW, which is a major producer of ferrosilicon, is the only Canadian manufacturer of silicon metal. It exports most of its ferrosilicon and silicon metal to the United States, Japan and West Germany.

SKW has three furnaces with an aggregate capacity of about 70 megawatts, which gives it an annual capability for producing about 40 000 t of ferrosilicon (50 per cent) and about 25 000 t of silicon metal. Its modern facility is equipped with a computerized material handling system for the charging of its furnaces.

Chromasco, a division of Timminco Limited located at Beauharnois, Quebec, is the only Canadian-owned ferrosilicon producer. Chromasco produces different grades of ferrosilicon, the 50 per cent grade accounting for about half of its production. Chromasco completed construction of a heavy media concentrator at its Beauharnois plant in 1986. The concentrator will be used to recover manganese from silicomanganese slag.

The abundance of relatively inexpensive electric energy also enables Canadian plants to produce and export bulk quantities of

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synthetic abrasives, such as silicon carbide (SiC) and fused alumina (Al_2O_3). Producers of these abrasives are located in Quebec and Ontario.

Silicon carbide was produced in both Quebec and Ontario in 1986. The two Quebec producers were The Norton Company, Abrasives Division at Cap-de-la Madeleine and Sohio Electro Minerals at Shawinigan. The Exolon-ESK Company of Canada, Ltd. in Niagara Falls, Ontario and General Abrasives Operations, Division of Dresser Canada, Inc. in Thorold, Ontario, produced both silicon carbide and fused alumina. The Norton Company, Sohio Electro Minerals and Washington Mills Abrasive Company have plants at Niagara Falls, Ontario, which produced fused alumina.

Canadian exports of ferrosilicon for the first nine months of 1986 were 35 473 t, exceeding exports for the same period in 1985 by 2 251 t, an increase of about 10 per cent. About 50 per cent of Canadian production was exported during these two years. The United States and Japan accounted for over 90 per cent of total exports.

Canada's exports of silicon carbide and fused alumina in 1986, estimated at 66 000 t and 125 000 t respectively, were about equal to those of 1985. The United States market accounted for over 90 per cent of total Canadian exports of these two products.

Canadian producers of silicon carbide and fused alumina operated at near capacity in 1985 and 1986, with the exception of Exolon-ESK which closed for two months in 1985 and for one month in 1986. Nearly all Canadian production of bulk synthetic abrasives is exported principally to the United States where the material is crushed, screened and classified. A small part of the processed material is reimported for the production of bonded abrasives, such as abrasive wheels, and coated abrasives such as sandpaper.

Canada does not produce silicon nitride, semi-conductor grade silicone and sialons. However, it is a producer of silicon metal, which when highly purified is used in the production of semi-conductor grade silicone.

INTERNATIONAL SCENE

Canada ranks fifth as a world producer of ferrosilicon and eighth as a world producer of silicon metal. Canada's annual production capacity for ferrosilicon is estimated at 8 per cent of world capacity and about 12 per cent of that of the western world.

The other major world producers of ferrosilicon are China, Norway, the United States, the Republic of Korea and Brazil.

The world annual production capability for silicon carbide in 1985 was estimated at 750 000 t. North American capacity was about 237 000 t, equivalent to that of western Europe and approximately double that of the Communist Bloc (U.S.S.R., Yugoslavia, Czechoslovakia, East Germany and China).

The major European producers of silicon carbide in 1985 and 1986 were Norway, France, Italy, West Germany and the Netherlands.

In the United States, the bills related to fair trade in ferroalloys, which were introduced in the first quarter of 1985, were being considered for inclusion in an omnibus trade bill. However, they were kept separate because they were considered too controversial. There was, nevertheless, some optimism that amendments to the ferroalloy bills could make them acceptable for inclusion in the omnibus trade bill.

Ohio Ferro-Alloys Corp. in Canton, Ohio, filed for reorganization of its finances in 1986, under chapter eleven of the bankruptcy regulations, citing continuing deficits and current low prices for ferroalloys as the reason for the action.

The United States is the world's largest producer of silicones and accounts for about 60 per cent of total world production. In 1985 and 1986, the United States was one of the world's largest consumers of silicones for the production of semi-conductors.

Japan imported 324 000 t of ferrosilicon in 1986, compared to 332 000 t in 1984. This country, which has become a net importer of ferroalloys, produced 115 000 t of ferosilicon in 1986, about 26 per cent less than in 1984. As well as being a major user of ferrosilicon, Japan consumed 57 000 t of silicon metal in 1986, which is about 35 per cent more than 1985.

Brazil has emerged as a potential major supplier of ferrosilicon and silicon metal to world markets. Capital investment in the 1980s for the production of ferroalloys was estimated at $US 700 million, of which about

40 per cent was planned for the production of ferrosilicon and silicon metal. This expansion will allow Brazil to increase its exports of silicon ferroalloys on world markets from about 108 000 t in 1986, which accounted for 12 per cent of world trade, to about 25 per cent by 1990. Seventy per cent of Brazil's current export trade is with Japan, the United States and West Germany. Based on Brazil's estimated steel production in 1986 (20.5 Mt) and its exports of ferrosilicon in that year, it was estimated that its ferrosilicon producers operated at about 85 per cent of capacity.

The fourth International Ferroalloy Congress (INFACON 86), hosted by the Brazil Ferroalloy Producers Association, was held in Rio de Janeiro, between August 31 and September 3, 1986. The conference was attended by about 500 participants. Concern was expressed at the conference about the new ferrosilicon capacity being brought on stream in view of the current excess capacity.

Overcapacity was also a major topic at the third International Ferroalloy Conference held in Monte Carlo, on November 6 to 8, 1985, particularly in view of the low growth rate forecasted in the short term. Attention was also drawn to the trend of building new capacity in locations of low-cost energy, for example Canada and Brazil.

Production capacity of ferrosilicon for the People's Republic of China was estimated at 200 000 t in 1986 and is expected to increase to 250 000 t by 1989. Norway, one of the world's leading ferroalloy producers has an annual ferrosilicon capacity of 850 000 t and a silicon metal capacity of about 190 000 t .

USES

The iron and steel industry, including the ferrous casting industry, is the largest user of ferrosilicon and other silicon ferroalloys such as magnesium ferrosilicon, silicomanganese, silicospiegeleisen and silicocalcium. Ferrosilicon accounts for the largest consumption of silicon ferroalloys, due to its use as a deoxidizer in the production of iron and steel, as an innoculant in the production of iron and as a nodularizing agent in the production of ductile iron. The other silicon ferroalloys are primarily used in the refining of iron and steel, including the production of ferrous castings.

Ferrosilicon also functions as a graphitizer in the production of iron and steel, which assists in increasing the ultimate tensile strength of these products. In addition, ferrosilicon improves the resistance of iron to scaling and expansion at elevated temperatures, and its corrosion resistance to mineral acids.

Carbon steel contains an average of about 4 kg of silicon per t of steel and accounts for about one third of Canada's consumption of ferrosilicon. Specialty steels contain between 10 to 15 kg of silicon per t. Ferrosilicon is also used for the production of magnesium and nickel by the siliconthermic process.

Silicon metal is used mainly as an alloying agent in the production of aluminum and magnesium silicon alloys. It can also be further processed to produce silicon tetrachloride or trichlorosilane. The reduction of these two compounds with hydrogen yields high-purity silicone, which is used in the production of electrical semi-conductors. The use of silicone, particularly in the field of high technology, is small (about 8 000 tpy), but this consumption is expected to increase fivefold by the year 2000. Other important uses of silicon include catalysts for the production of oil, synthetic rubber and plastic resins.

The use of silicon in nonferrous metals improves the fluidity and wear resistance of aluminum alloys and the strength, weldability, corrosion and galling resistance of copper bronzes.

The consumption of silicon metal is growing in the production of aluminum and magnesium castings for the aerospace and automobile industries.

Silicon carbide is used mainly in the production of abrasives for use in finishing operations in the metal and woodworking industries. These two uses account for about 70 per cent of its consumption. About 20 per cent is consumed in the manufacture of refractory bricks for metallurgical purposes and in the production of ductile iron. Silicon carbide competes with ferrosilicon in the production of ductile iron produced by electric furnaces. Its use has increased in the 1980s in response to the strong demand for ductile iron by the automotive industry due to high-strength low-weight characteristics and technological developments that have made ductile iron more cost-competitive than other grades of iron.

Silicon nitride, which is also produced from silicon metal, is used for refractory coatings, bonding of silicon carbide, abrasives, mortars, crucibles, thermocouples, rocket nozzles and as a coating on tungsten inserts. The finished products have applications in foundry finishing operations, welding, diecasting jigs and fixtures, and heat treating. The nitride is generally incorporated in these products by the Reaction Bonded Silicon Nitride (RBSN) process. The Hot Pressed Silicon Nitride (HPSN) process gives a stronger product which is used in metal cutting, tube drawing and specialized chemical industries.

OUTLOOK

The world silicon ferroalloy industry is expected to remain depressed until the year 1990, due mainly to overcapacity. While the global market outlook is not encouraging, the Canadian ferrosilicon and silicon metal industry will remain competitive due to the availability of low-cost hydro-electric power and a favourable exchange rate for the Canadian dollar.

Norway will remain a major supplier of silicon ferroalloys to world markets, and China and Brazil will become major suppliers to these markets by the year 1990.

China has increased its ferrosilicon capacity by 50 000 tpy. It has indicated that this new capacity will be used to satisfy its domestic silicon ferroalloy requirements, which are mainly for increasing secondary aluminium production.

The increase in capacity in the People's Republic of China and Brazil (160 000 t) will not substantially alter the world total which currently stands at 3.1 million t. These expansions will replace existing capacity in Japan, Europe, and the United States, which is expected to close by 1993 due to plant obsolescence and high energy costs.

Canada's exports of silicon carbide and fused alumina (crude and grains) is forecasted to increase about 1 per cent per annum to the year 1990 in response to increased demand in the metallurgical, metal finishing and wood working industries in the United States.

PRICES

As published by **METALS WEEK** in December 1985 and 1986		1985	1986
		(¢US)	
Ferrosilicon, U.S. producer, per pound of silicon content; lump bulk lots, f.o.b. shipping point			
High-purity 75% Si		40.00 - 47.00	40.00 - 47.00
Regular 50% Si		40.00 - 45.00	40.00 - 45.00
Silicon metal, per pound of contained silicon, f.o.b. shipping point, lump, bulk and carload lots,			
(% max. Fe)	(% max. Ca)		
0.35	0.07	67.35 - 68.85	67.35 - 68.85
0.50	0.07	65.05 - 66.55	66.05 - 66.65
1.00	0.07	56.00 - 57.50	62.00 - 63.75
Silicomanganese, U.S. producer, per pound, 2% carbon, lump bulk lots, f.o.b. shipping point		23.50	23.50
Prices published by **AMERICAN METAL MARKET** in December 1985 and 1986		(¢US)	
SMZ alloy: 60-65% Si, 5-7% Mn, 5-6% Zr, ¼ inch mesh, per pound of alloy		55.90	55.90
Calcium-silicon and calsibar alloy, f.o.b. producer, 15-ton lots, per pound		72.00	72.00
Prices published by **INDUSTRIAL MINERALS** in December 1985 and 1986 (tonnes, cif main European port)		(£)	
Fused alumina, 8-220 mesh, cif			
Brown, min. 94% Al_2O_3		350.00 - 420.00	320.00 - 440.00
White, min. 99.5% Al_2O_3		410.00 - 500.00	420.00 - 600.00
Silicon carbide, 8-220 mesh, cif			
Black, about 99% SiC - Grade 1		700.00 - 750.00	700.00 - 750.00
- Grade 2		600.00 - 700.00	600.00 - 700.00
Green, over 99.5% SiC		850.00 - 950.00	850.00 - 950.00

f.o.b. Free on board; cif Cost, insurance and freight.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(cents)		
CANADA					
	Ferro-alloys:				
37502-1	Silico-manganese - silico spiegel and other alloys of manganese and iron containing more than 1%, by weight of silicon - per pound or fraction thereof, on the manganese contained therein	free	0.71	1.75	free
37503-1	Ferro-silicon, being an alloy of iron and silicon containing 8% or more, by weight of silicon and less than 60% - per pound, or fraction thereof, on the silicon contained therein	free	free	1.75	free
37504-1	Ferro-silicon, being an alloy of iron and silicon containing 60% or more, by weight, of silicon and less than 90% - per pound or fraction thereof, on the silicon contained therein	free	0.72	2.75	free
37505-1	Ferro-silicon, being an alloy of iron and silicon containing 90% or more, by weight, of silicon - per pound or fraction thereof, on the silicon contained therein	free	2.1	5.5	free
92804-1	Silicon metal:	9.9	9.9	25.0	6.5
92815-4	Silicon sulphide	9.9	9.9	25.0	6.5

MFN Reductions under GATT (effective January 1 of year given)	1986	1987
	(cents)	
37502-1	0.71	0.7
37504-1	0.71	0.7
37505-1	2.1	2.0
	(%)	
92804-1	9.9	9.2
92815-4	9.9	9.2

UNITED STATES (MFN)

519.21	Crude silicon carbide:	free
519.37	Silicon carbide in grains, ground, pulverized or refined:	0.3¢/lb.
606.35	Ferrosilicon, containing over 8% but not over 60% by weight of silicon	free

TARIFFS (cont'd)

UNITED STATES (cont'd)		1986	1987
		(%)	
	Ferrosilicon, containing over 60% but not over 80% by weight of silicon:		
606.36	Containing over 3% by weight of calcium	1.1	1.1
606.37	Other	1.5	1.5
606.39	Ferrosilicon, containing over 80% but not over 90% by weight of silicon:	6.5	5.8
606.42	Ferrosilicon chromium	10.0	
606.44	Ferrosilicon manganese	4.2	3.9

EUROPEAN ECONOMIC COMMUNITY (MFN)		1986	Base Rate	Concession Rate
			(%)	
28.13	Silicon dioxide:	4.6	6.4	4.6
	Ferro-alloys:			
73.02	Ferrosilicon	6.2	10.0	6.2
	Ferrosilico-manganese	5.5	5.5	5.5
	Ferrosilico-chrome	4.9	7.0	4.9
JAPAN (MFN)				
	Silicon:			
28.04	of single crystal	8.2	15.0	7.2
	other	5.1	7.5	4.9
28.56	Silicon carbide	5.2	7.5	4.9
68.06	Abrasive paper	7.6	15.0	6.5
73.02	Ferrosilicon	3.9	5.0	3.7

Sources: The Customs Tariff 1986, Revenue Canada Customs and Excise; Tariff Schedules of the United States Annotated (1986), USITC Publication 1775; U.S. Federal Register, Vol. 44, No. 241; Customs Tariff Schedules of Japan, 1986; Official Journal of the European Communities, Vol. 28, No. L331/120, 1986.

TABLE 1. CANADA, SILICON TRADE, 1984-86

	1984^r		1985^P		1986^e	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Exports						
Ferrosilicon						
United States	15 525	7,805	20 986	11,371	37 600	24,003
Japan	18 315	17,342	12 060	11,319	8 500	7,780
South Korea	247	259	-	-	497	7,460
United Kingdom	619	449	141	90	142	32
Australia	-	-	-	-	36	25
Dominican Republic	230	193	35	35	-	-
Mexico	6	5	-	-	-	-
Netherlands	211	193	-	-	-	-
Philippines	1	1	-	-	-	-
Total	35 154	26,251	33 222	22,815	46 775	39,300
Silicon carbide, crude and grains						
United States	65 031	40,019	65 106	36,684	66 080	37,751
Colombia	-	-	80	54	-	-
Algeria	-	-	3	1	-	-
Total	65 031	40,019	65 189	36,740	66 080	37,751
Imports						
Ferrosilicon						
United States	24 408	19,050	11 873	13,254	11 520	12,762
West Germany	286	346	84	97	166	270
Norway	-	-	59	85	25	125
Brazil	10	13	11	16	-	-
France	71	84	47	50	-	-
Total	24 775	19,495	12 074	13,505	11 711	13,157
Silicomanganese, including silicon spiegel						
Norway	100	58	707	411	3 164	1,567
United States	651	372	2 786	1,916	516	508
Brazil	2	2	1 067	490	1 000	445
South Africa	6 077	2,574	2 040	875	-	-
Total	6 830	3,008	6 600	3,693	4 680	2,520

Source: Statistics Canada.
P Preliminary; ^{r} Revised; ^{e} Estimated; - Nil.

TABLE 2. CANADA, CONSUMPTION, EXPORTS, IMPORTS AND PRODUCTION OF FERROSILICON, 1975, 1980-86

	Consumption[1]	Exports		Imports		Production[2]
	(tonnes)	(tonnes)	($ 000)	(tonnes)	($ 000)	(tonnes)
1975	54 904	29 029	8,075	26 353	15,665	57 580
1980	63 321	52 164	33,886	18 508	13,869	96 977
1981	62 090	52 410	36,722	18 629	15,605	95 871
1982	46 122	40 872	29,209	19 860	11,029	67 134
1983	50 022	45 715	32,381	13 079	12,729	95 737
1984^{r}	58 070	35 154	26,251	24 775	19,496	63 349
1985P	55 957	33 222	22,816	12 074	13,505	71 105
1986^{e}	56 500	46 775	39,300	14 000	15,000	89,500

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Consumption as reported by consumers. [2] Consumption plus net exports equals derived production.
P Preliminary; ^{r} Revised; ^{e} Estimated.

TABLE 3. CANADA, MANUFACTURERS' SHIPMENTS OF CRUDE SILICON CARBIDE 1975, 1980-84

	(tonnes)	($ 000)
1975	89 346	24,597
1980	86 353	46,897
1981	89 997	50,758
1982	71 518	42,913
1983	73 217	43,756
1984	81 622	49,575

Source: Statistics Canada.

TABLE 4. CANADA, EXPORTS OF SILICON CARBIDE, CRUDE AND GRAINS 1975, 1980-86

	(tonnes)	($ 000)
1975	78 615	17,441
1980	72 414	33,244
1981	67 144	34,595
1982	57 884	30,892
1983	64 707	40,457
1984^{r}	65 031	40,020
1985P	65 189	36,740
1986^{e}	66 080	37,752

Source: Statistics Canada.
P Preliminary; ^{r} Revised; ^{e} Estimated.

TABLE 5. CANADA, MANUFACTURERS' SHIPMENTS OF CRUDE FUSED ALUMINA 1975, 1980-84

	(tonnes)	($ 000)
1975	110 736	26,162
1980	146 655	56,957
1981	149 840	57,949
1982	114 479	53,816
1983	111 225	51,656
1984	140 874	66,622

Source: Statistics Canada.

TABLE 6. CANADA, EXPORTS OF FUSED ALUMINA, CRUDE AND GRAINS, 1975, 1980-86

	(tonnes)	($ 000)
1975	127 658	26,650
1980	183 124	55,138
1981	157 990	67,954
1982	114 551	55,492
1983	109 864	57,568
1984^{r}	138 831	80,407
1985P	129 310	69,563
1986^{e}	124 608	69,255

Source: Statistics Canada.
P Preliminary; ^{r} Revised; ^{e} Estimated.

TABLE 7. CANADA, EXPORTS BY COUNTRY OF DESTINATION FOR FUSED ALUMINA AND SILICON CARBIDE, 1984-86

	1984^r		1985P		1986^e	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Fused alumina, crude and grains						
United States	126 484	75,480	116 568	63,767	115 800	66,459
United Kingdom	12 310	4,892	12 724	5,783	8 400	2,436
Belgium-Luxembourg	-	-	-	-	300	271
West Germany	-	-	-	-	58	43
Denmark	-	-	-	-	30	32
France	-	-	18	13	20	14
Austria	37	34	-	-	-	-
Total	138 831	80,407	129 310	69,563	124 608	69,255
Silicon carbide, crude and grain						
United States	65 031	40,019	65 106	36,684	66 080	37,752
Colombia	-	-	80	54	-	-
Algeria	-	-	3	1	-	-
Total	65 031	40,019	65 189	36,740	66 080	37,752

Source: Statistics Canada.
^{e} Estimated; - Nil; P Preliminary; ^{r} Revised.

Silver

D. LAW-WEST

In 1986, silver prices continued to weaken, unlike gold and platinum which saw major price increases. Estimated western world production decreased by about 3 per cent from 10 250 t in 1985 to 10 000 t in 1986. Canadian silver production showed a slight increase of 23 t to 1 220 t in 1986. World silver demand is believed to have remained relatively unchanged from the 12 100 t in 1985. The outlook for silver prices is for little change and continued weakness due to the large stockpiles which overhang the market.

CANADIAN DEVELOPMENTS

Silver production in New Brunswick increased to 200 t in 1986, 14 per cent above 1985 output due to higher production by Brunswick Mining and Smelting Corporation Limited. In Quebec, lower base metal output led to a 20 per cent drop in silver production from that province.

In Ontario, Canada's largest producer of silver, a small decrease in production from 455 t to 437 t was recorded in 1986. The main reason was the destruction by fire of the Penn mill of Agnico-Eagle Mines Limited. The company expects to have a 300 tpd replacment mill, built at a cost of $2.5 million, in operation in early-1987.

Joint venture partners, Silverside Resources Inc. and International Platinum Corporation (formerly Silver Lake Resources Inc.), are planning to develop the Hellens Eplett silver property near Cobalt. About $5 million has been spent on the project including a 1 000 m ramp and a 100 m raise. Intensive underground drilling has been completed as well as a 625 t bulk sample test which averaged 810 g/t (26 oz/t). Ore reserves are expected to be in excess of 100 000 t grading nearly 1 kg/t. Operating costs of a 150 tpd operation are estimated at $3.80 per ounce of silver.

Manitoba and Saskatchewan reported drops of 6 t and 3 t in silver production, respectively, in 1986. Reduced base-metal output accounted for these drops.

Silver production in British Columbia increased by 25 t in 1986 to 405 t. Expansion of the mill at Equity Silver Mines Limited increased daily throughput from 5 715 tpd to 9 890 tpd and production increased by nearly 15 t in 1986. The new Blackdome mine near Clinton accounted for some of the remaining increase in silver production. Blackdome Mining Corporation began operating in May and expects to produce 1 400 kg of gold and 6 200 kg of silver annually.

The Mount Skukum mine, owned 63 per cent by AGIP Canada Ltd. and 37 per cent by Total Erickson Resources Ltd., added a significant amount of silver to the Yukon Territory's total by producing about 6 000 kg after start-up in mid-1986. United Keno Hill Mines Limited also accounted for part of the increase as it drew a larger percentage of mill feed from higher-grade underground sources.

Silver production in the Northwest Territories dropped to 23 t from 33 t in 1985, mainly because the Camsell River mine of Terra Mines Ltd. remained closed throughout the year.

Canadian consumption of silver will show an increase in 1986 and the following year as a result of the Olympic Coin Program. The program will use 155 t (5 million ounces) to produce 500,000 sets of the ten coins, with each coin containing one ounce of silver.

There are three major silver refineries in Canada responsible for treating most of the country's newly mined silver. The largest is the CCR Division of Noranda Mining Inc. with a capacity of 930 tpy. Cominco Ltd., which operates a 435 tpy silver refinery at

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Trail, British Columbia is the second largest Canadian silver refiner. Agnico-Eagle Mines Limited operates a 93 tpy refinery at Cobalt, Ontario, with most of its feed material coming from nearby silver mines.

Secondary silver is recovered at refineries operated by Johnson Matthey Limited, Degussa Canada Ltd., Handy & Harman of Canada, Limited, Engelhard Industries of Canada Limited and Noblex Métal Corporation Limitée.

INTERNATIONAL DEVELOPMENTS

Preliminary estimates of western world silver production indicate a 3 per cent decrease from the 10 250 t in 1985 to about 10 000 t in 1986.

Mexico remained the largest silver producer, increasing its production slightly to 2 100 t in 1986. Mexican silver production is expected to remain at about 2 000 tpy as producers such as the Real de Angeles and the San Martin mines are able to produce at prices below $US 5.00 per ounce.

Peru, the second largest producer, suffered a drop in production as the result of a labour dispute at the Empresa Minera del Centro del Peru S.A. (Centromin-Peru) facilities early in the year. Production for the year is estimated at 1 770 t.

United States production of silver fell in 1986 due to the closure of several mines because of low silver prices. Estimated production in 1986 was 980 t compared to 1 225 t in 1985. In Idaho, the largest silver producing state, four mines were shut down during the year because of poor prices, including the Lucky Friday mine of Hecla Mining Company and the Sunshine mine of Sunshine Mining Company, the country's two largest producers. However, production in the United States should recover in 1987 when by-product silver from several new gold mines comes on-stream.

Silver prices on the London Metal Exchange averaged $US 5.46 per ounce in 1986, down from $6.14 in 1985. The market was again relatively quiet for most of the year with the prices fluctuating within a $1.45 range.

CONSUMPTION AND USES

World silver consumption increased slightly to an estimated 12 100 t in 1985, compared to 1984. This was mainly due to increased demand for photography, electronic equipment, sterling ware and jewelery.

Photography is the largest single use for silver, accounting for about 40 per cent of industrial consumption. While silver use by this industry has been rising over the past three years, it remains nearly 10 per cent below consumption in the late-1970s. The high silver prices of 1979 and 1980 led the photographic industry to reduce the amount of silver used per exposure, while increasing the silver recovered from spent photographic materials. Colour and black and white photographs account for some 55 per cent of silver used in photography, x-ray photographs account for about 35 per cent, while the remaining 10 per cent is broadly utilized in graphic arts, engineering and other industrial uses. Each of these sectors face different conditions that affect the amount of silver consumed. The colour and black and white photographic print business faces competition from silver-free technology such as electronic or video photo-imaging. However, the number of amateur photographers is growing and demand for photographic materials is increasing, particularly in developing countries. According to some analysts the use of silver in this sector should continue to grow over the next few years.

Since the x-ray sector is mainly centred around hospitals, there is fairly complete recycling of used x-ray films. The rate of recycling depends upon the length of time that x-ray records are retained. The major threat to silver x-ray prints is from the digital storage of x-ray images using chromium-dioxide video tapes. In addition, traditional x-ray machines are facing competition from other machines such as cat scanners and nuclear magnetic rosand units which could easily be linked with non-silver, video-recording equipment in lieu of the traditional silver-based x-ray prints.

The electrical and electronic industry accounts for about 30 per cent of consumption. Silver's superior electrical conductivity accounts for its extensive use in contacts, conductors, resistors and capacitors. Silver is preferred where a high degree of dependability is required. Spacecraft, satellites and aircraft guidance systems are typical examples. Also, silver-zinc and silver-cadmium batteries are used in spacecraft and jet aircraft. Consumption in the electronics industry will increase with the growing popularity of home entertainment units such as video cassette recorders and home microcomputers. However, the move toward miniaturization will in part offset the increased numbers.

Sterling ware and jewellery together account for about 5 per cent of consumption. Silver usage in these industries has declined substantially since the mid-1970s. At that time, sterlingware producers in the United States used 22-30 million ozs. while jewellers required about 13 million ozs.

The remaining 25 per cent of industrial silver is used mainly in catalysts for chemical processing, mirrors, brazing alloys and solders, electroplating, dental amalgams, medical equipment, chemicals, coins, medallions and commemorative objects.

OUTLOOK

The gold-silver price ratio showed a further increase in 1986, reaching a high of nearly 80:1, well above the previous year's high of 56:1. This may be an indication that silver is losing its investor appeal. The short-term outlook for silver is rather flat with no indications of a price rally.

The longer term outlook for silver remains rather bleak. There is no indication that the metal should return to a more favorable price ratio with gold. The major concern is the large stocks of silver that overhang the market in both the private and public domains. World production is not likely to decline sufficiently to reduce the stocks and hence cause a significant price increase.

TABLE 1. CANADA, SILVER PRODUCTION AND TRADE, 1984-86

	1984		1985		1986P	
	(kilograms)	($000)	(kilograms)	($000)	(kilograms)	($000)
Production[1]						
By province and territories						
British Columbia	360 743	125,585	379 277	105,773	405 272	103,093
Ontario	541 345	188,457	455 644	127,070	437 212	111,218
New Brunswick	217 154	75,597	175 419	48,921	200 608	51,031
Quebec	46 937	16,340	61 436	17,133	49 703	12,643
Manitoba	35 519	12,365	40 179	11,205	34 227	8,707
Saskatchewan	5 273	1,836	5 581	1,556	2 627	671
Yukon Territories	57 074	18,825	46 966	13,098	66 425	16,897
Northwest Territories	58 487	20,361	32 570	9,083	22 966	5,842
Total	1 326 720	461,868	1 197 072	333,839	1 219 050	310,102
Exports						
Silver in ores and concentrates					(Jan.-Sept.)	
Japan	201 857	48,728	235 105	47,517	183 206	33,365
United States	103 143	27,604	32 026	5,032	25 376	5,056
Belgium-Luxembourg	18 022	3,393	9 667	1,893	13 546	2,041
West Germany	15 792	2,386	16 348	1,728	4 480	429
Switzerland	17 614	4,868	-	-	-	-
Other countries	67 535	15,164	38 183	5,414	27 415	39,590
Total	423 963	102,143	331 339	61,584	254 023	49,850
Refined metal						
United States	1 079 539	363,829	1 323 919	359,770	838 403	205,027
Trinidad-Tobago	236	92	224	93	19	5
Dominican Republic	181	35	18	40	558	32
United Kingdom	379	114	171	134	840	223
Other countries	1 056	779	663	96	2 484	660
Total	1 081 391	364,849	1 324 995	360,133	842 304	205,947
Imports						
Silver in ores and concentrates						
Peru	78 503	20,353	53 048	11,467	53 123	9,055
Chile	14 907	4,770	9 569	2,279	5 067	1,026
United States	25 653	7,642	11 572	2,700	12 613	3,068
Spain	9 031	1,958	14 413	3,123	7 499	1,253
Bolivia	1 678	463	3 687	816	2 093	461
Other countries	18 006	5,875	8 227	1,188	1 979	352
Total	147 778	41,061	100 516	21,573	82 374	15,215
Refined metal						
United States	195 968	62,714	537 296	145,702	138 552	32,593
Mexico	8 921	4,974	9 063	4,216	1	2
West Germany	1 036	238	8 663	2,139	2 532	507
Belgium-Luxembourg	-	-	16 794	4,583	-	-
Chile	7 999	3,197	-	-	-	-
Others	1 268	316	1 279	156	6 376	1,429
Total	215 192	71,439	573 095	156,796	147 460	34,531

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Includes recoverable silver in: ores, concentrates and matte shipped for export; crude gold bullion produced; blister and anode copper produced at Canadian smelters; and base and other bullion produced from domestic ores.

P Preliminary; - Nil.

TABLE 2. CANADA, SILVER PRODUCTION, TRADE AND CONSUMPTION, 1970, 1975, AND 1979-86

	Production[1]	Exports In Ores and Concentrates	Exports Refined Silver	Exports Total	Imports, Refined Silver	Consumption[2] Refined Silver
			(kilograms)			
1970	1 376 354	678 676	752 689	1 431 365	134 347	187 679
1975	1 234 642	471 410	713 566	1 184 976	420 078	642 089
1979	1 146 908	415 726	911 146	1 326 872	38 308	251 985
1980	1 070 000	396 690	881 761	1 278 451	339 180	265 938
1981	1 129 394	546 449	914 800	1 461 249	327 328	292 130
1982	1 314 000	602 603	1 134 347	1 736 950	484 240	180 459
1983	1 197 031	439 406	1 045 867	1 485 273	339 439	283 349
1984	1 326 720	423 963	1 081 391	1 505 354	215 192	299 440
1985	1 197 072	331 339	1 324 995	1 656 334	573 095	..
1986P	1 219 050	254 023[3]	842 304	1 096 327	147 460	..

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Includes recoverable silver in: ores, concentrates and matte shipped for export; crude gold bullion produced; blister and anode copper produced at Canadian smelters; and base and other bullion produced from domestic ores. [2] In some years includes only partial consumption for coinage. [3] 1986 exports and imports are for nine months.
P Preliminary; .. Not available.

TABLE 3. WORLD MINE PRODUCTION[1] OF SILVER, 1985 AND 1986

	1985	1st 6 Months 1986
	(tonnes)	
U.S.S.R.[e][2]	1 600.0	800.0
Mexico	2 153.0	987.7
Peru	1 766.8	919.6
Canada[3]	1 197.1	536.2
United States	1 205.2	552.9
Australia	1 062.9	529.4
Poland[e]	744.0	375.0
Chile	517.6	255.0
Japan	339.5	169.8
Republic of South Africa	209.0	107.9
Bolivia	111.4	41.6
Sweden	189.8	106.1
Yugoslavia[e][2]	156.0	87.0
Spain	199.2	99.6
Morocco	139.0	69.5
Namibia	105.5	52.8
South Korea	69.6	34.8
Argentina	62.0	45.0
Philippines	54.2	28.4
People's Republic of China[e]	90.0	45.0
Greece	50.7	25.3
Italy	71.5	35.9
France	26.9	13.3
Other countries[e]	560.9	28.0
Total	12 681.8	6 197.9

Source: World Bureau of Metal Statistics.
[1] Recoverable content of ores and concentrates produced unless otherwise noted.
[2] Smelter and refinery production.
[3] Energy, Mines and Resources Canada.
P Preliminary; [e] Estimated.

TABLE 4. ANNUAL AVERAGE SILVER PRICES: CANADA, AND UNITED STATES 1975-86

	Canada	United States Handy & Harman, New York
	($Cdn)	($US)
	(per troy ounce)	
1975	4.50	4.42
1976	4.29	4.35
1977	4.92	4.62
1978	6.17	5.40
1979	12.97	11.09
1980	24.10	20.63
1981	12.62	10.52
1982	9.83	7.94
1983	14.15	11.44
1984	10.52	8.14
1985	8.36	6.14
1986	7.53	5.46

Source: Canadian prices as quoted in the Northern Miner (arithmetical average of daily quotations).

Sodium Sulphate

G.S. BARRY

Sodium sulphate is mainly produced from natural brines and deposits in alkaline lakes in areas with dry climates and restricted drainage, from subsurface deposits and brines, or as a by-product of chemical processes. Canada's sodium sulphate industry is based on extraction from natural brines and deposits in several alkaline lakes in Saskatchewan and Alberta. Seven plants producing natural sodium sulphate operated in Canada in 1986. By-product sodium sulphate is recovered at one rayon plant and at three paper mills in Ontario.

World production in 1986 was estimated at approximately 4 million t, split about 44 per cent from natural sources and 56 per cent from various manufacturing processes, mainly as a by-product of viscose rayon production, hydrochloric acid, sodium dichromate and about six other chemical processes.

In the United States, natural and by-product sodium sulphate production is almost evenly split. In Europe, sodium sulphate is produced almost entirely as a by-product of chemical processes.

PRODUCTION AND DEVELOPMENTS IN CANADA

Demand for Canadian natural sodium sulphate remained stable but much below capacity levels for the past few years. The Saskatchewan and Alberta producers responded to this stagnant demand by reducing gradually production levels by approximately 32 per cent between 1982 and 1986. The average unit value of shipments remained essentially constant at $93.92 per t in 1983; $96.90 in 1984; $92.49 in 1985 and $90.10 in 1986. Exports to the United States increased marginally by 0.6 per cent for the first nine months of 1986 compared to the same period last year.

Besides natural sodium sulphate, about 90 000 tpy are produced as a by-product of industrial and chemical processes in central Canada. Between 35 and 40 per cent of the total amount of sodium sulphate produced in Canada is the higher-grade and higher-priced "detergent-grade".

Potash Corporation of Saskatchewan (PCS) completed the construction of a $10 million potassium sulphate demonstration plant at its Cory potash mine near Saskatoon. The plant has a designed capacity of 30 000 tpy. The production of potassium sulphate is achieved through a reaction of sodium sulphate with potassium chloride (glaserite process). Glaserite is tracked directly from one of the sodium sulphate producers. Start-up problems were experienced, particularly with compaction of potassium sulphate, but have now been solved. In late 1986, capacity utilization was approximately 50 per cent. The plant follows the 10 days on, 4 days off schedule as adopted intentionally for the potash mine. By mid-1987, the plant should be operating at optimum levels. Commercial shipments of potassium sulphate on a consistent basis started in mid-1986.

In the fall of 1986, PCS started the construction of a 10 tpd, pilot size plant for the production of industrial grade potassium sulphate at Big Quill Lakes. The completion of this plant is scheduled for April 1987. The company completed a feasibility study on a large potassium sulphate plant based on sulphate brines of Big Quill Lakes. Depending on technical and market factors, such a plant could have a capacity of up to 300 000 tpy of product and would cost somewhat less than $100 million. A decision on whether to proceed with a plant of this size has not yet been made.

In January 1985, Alberta Sulphate Limited, then entirely owned by Agassiz Resources Ltd., bought the Francana operations from Hudson Bay Mining and Smelting Co., Limited. The two deposits in Saskatchewan (Snakehole and Alsask Lakes) and the deposit in Alberta (Metiskow Lake) are now all operated under the name: Francana Minerals, Inc. a division of Agassiz Resources Ltd.

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Deposits. The sodium sulphate deposits in Saskatchewan and Alberta have formed in shallow, undrained lakes and ponds where inflow is greater than outflow. Percolating ground waters carry dissolved salts into the basins from the surrounding soils. High rates of summer evaporation concentrate the brine to near saturation, and cooler fall temperatures cause crystallization and precipitation of sodium sulphate as mirabilite ($Na_2SO_4 \cdot 10H_2O$). The cycle has been repeated year after year and thick deposits of hydrous sodium sulphate, accompanied by other salts and mud, have accumulated.

Identified deposits in Saskatchewan contain, in total, approximately 90 million t of anhydrous sodium sulphate. Of this amount, a total of about 51 million t is in 21 individual deposits, each containing more than 500 000 t of sodium sulphate. Exploitation currently takes place on the following lakes (with reserves, in millions of t, in brackets): Whiteshore Lake (6.0), Horseshoe Lake (2.7), Chaplin Lake (2.4), Ingebrigt Lake (8.1), Alsask Lake (2.0), East Coteau Lake (3.4), and Snakehole Lake and Verlo Lake (1.2), all in Saskatchewan. Production in Alberta is from Metiskow Lake (0.9).

Recovery and processing. Because most of the sodium sulphate is recovered by evaporation of concentrated brines or by dredging of the permanent beds of crystals, weather is as important for recovery of sodium sulphate as it is for its deposition. A large supply of fresh water is also essential. One method of sodium sulphate recovery is to pump lake brines that have been concentrated by hot summer weather into evaporating ponds or reservoirs. Continued evaporation produces a saturated or near-saturated solution of mirabilite. Differential crystallization occurs in the fall when the solution cools. Hydrous sodium sulphate crystallizes and precipitates, whereas sodium chloride, magnesium sulphate and other constituents remain in solution. Before freezing weather sets in, the impure solution remaining in the reservoir is drained or pumped back into the source lake. After the crystal bed has become frozen, harvesting is carried out using conventional earth-moving equipment. The harvested crystal is stockpiled adjacent to the plant.

Some operators used floating dredges to mine the permanent crystal bed. The slurry of crystal and brine is transported to a screening house at the plant by pipeline. If sufficiently concentrated, the brine from the screens is collected in an evaporation pond.

Since 1984, one company uses solution mining in lake beds that are 3 to 11 m thick. It pumps a concentrated brine to an air-cooled crystallizer at the plant where sodium sulphate is separated from other more soluble salts.

Processing of the natural salt consists of dehydration (Glauber's salt contains 55.9 per cent water of crystallization) and drying. Commercial processes used in Saskatchewan include Holland evaporators, gas-fired rotary kilns, submerged combustion and multiple effect evaporators. Subsequent crushing and screening results in a product with uniform grain size and good flow characteristics. Salt cake, the product used principally in the pulp and paper industry, contains a minimum of 97 per cent Na_2SO_4. Detergent-grade material analyzes up to 99.7 per cent Na_2SO_4. Uniform grain size and free-flow characteristics are important in material handling and use.

Of the seven plants in the Prairies, four are capable of producing detergent-grade sodium sulphate. Three plants have the capacity to produce 80 per cent or more of their output as a high-grade product. The "natural" sodium sulphate industry employs about 300 persons.

By-product recovery. Courtaulds (Canada) Inc. produced in 1986 approximately 18 000 t of detergent-grade sodium sulphate as a by-product of viscose rayon production at its Cornwall, Ontario plant. Maximum capacity at the Cornwall plant would be in the order of 24 000 tpy.

Ontario Paper Company Limited at Thorold, Ontario produced approximately 67 000 t of salt cake in 1986 as a by-product of paper manufacturing. It is mostly used in the glass industry and 80 per cent is exported. The capacity of the Thorold plant is 77 000 tpy.

PRICES

Canadian prices of natural sodium sulphate f.o.b. western plants were approximately $80 and $100 per t respectively for salt cake and detergent-grade in 1986. Prices for detergent-grade by-product sodium sulphate in Ontario were in the order of $170 to $165 per t (for bulk). Freight costs for natural sodium sulphate delivered to Ontario are just over $75 per t.

USES

The main end-uses for sodium sulphate are in the pulp and paper, detergent, glass and dyeing industries.

In the chemical pulping of wood, the digestion reagents consist of about two-thirds caustic soda and one-third sodium sulphide obtained by using sodium sulphate as make-up. About 33 per cent of sulphur input is retained in the organic chemicals recycled in the process. Lately, technical improvements in the process significantly reduced the consumption of sodium sulphate per t of pulp produced, to 20 kg/t or less. More caustic soda and emulsified sulphur is being substituted for salt cake. Partial substitution reduces the emission of sulphur, thus facilitating compliance with stricter environmental controls.

Sodium sulphate is used as a builder; or more correctly as a diluent in detergents (supplies "bulk"); it is claimed to improve detergency through its effect on the colloidal properties of the cleaning system. The curtailment in the usage of phosphates on grounds of pollution control necessitated added substitution of phosphates by sodium sulphate. The average sodium sulphate content of powder detergents is now around 30 per cent. Roskill Information Services Ltd. estimates that sodium sulphate used in detergents of all types accounted for 21 per cent of world consumption (1983). In the United States, a recent rapid growth for liquid detergents has had a negative impact on sodium sulphate demand.

Some sodium sulphate is used by the glass industry as a source of Na_2O to speed melting and to prevent scum forming on the surface of the melt. For typical container glass, sodium sulphate used is 0.36 per cent of the weight of the glass produced. In other glass the sodium sulphate content can be much higher. However, particularly in the manufacture of flat glass, calcium sulphate and soda ash can partially replace sodium sulphate.

Sodium sulphate is used in the textile industry in the dyeing process, particularly of wool.

Sodium sulphate is used in the manufacture of a number of chemicals such as potassium sulphate, sodium sulphide, sodium silicate, sodium hyposulphite and sodium aluminum sulphate. Sodium sulphide is quantitatively the most important and is used for de-hairing hides in the tanning process.

Other end-uses include the manufacture of viscose sponges, feed supplements, boiler feed water treatments, veterinary medicines, sulphonated oils, printing inks, the ceramic industry and the photographic industry.

Since 1981, a potential new use for sodium sulphate was in coal-fired power plants. Sodium sulphate is added to coal as a conditioner since it improves the efficiency of high-temperature electrostatic precipitators by preventing clogging by fly-ash. Only about 5 kg of sodium sulphate is used for a t of coal. However, acceptance of this usage is disappointing and only two plants in the United States are known to be using this process.

Experiments were conducted in using sodium sulphate as a heat storage medium in solar energy conservation (heating) projects. To date, usage is limited, however, and it appears that another chemical, calcium chloride hexahydrate is a better material for heat-storage cells.

In the United Kingdom, research is conducted on a scrubbing liquor using sodium sulphate to remove sulphur dioxide and nitrogen from stack gas.

OUTLOOK

On balance the natural sodium sulphate industry is expected to experience a flat growth in consumption over the next few years.

Canadian shipments in 1986 were marginally higher than in 1985, a year of low-level activity. It appears that the substitution of sodium sulphate by caustic soda and emulsified sulphur in the North American pulp and paper industry almost ran its course and from 1987 onward, there is even a possibility of a very small increase in this vital market.

In the detergent industry a world wide growth of 1 and 2 per cent is still possible, but in the United States, the rapid substitution of powder detergents by liquid detergents may result in a slight overall decline in sodium sulphate consumption.

The United States consumes a quarter of the world production of sodium sulphate. Consumption in the United States averaged above 1.0 million t for the past few years but in 1986 it fell to just below 900 000 t and is expected to remain below 1.0 million t for the next two years.

For the world, the medium-term forecast growth rate in demand is 1.2 to 1.4 per cent per year from a 1984 base of 4.0 million t.

TABLE 1. CANADA, NATURAL SODIUM SULPHATE PRODUCTION AND TRADE, 1984-86

	1984		1985		1986P	
	(tonnes)	($)	(tonnes)	($)	(tonnes)	($)
Production						
Shipments						
Saskatchewan	..	33,517,773	..	30,236,681	..	29,315,052
Alberta	..	3,993,220	..	3,634,116	..	4,098,000
British Columbia	..	190,563	-	-	-	-
Total	389 086	37,701,556	366 217	33,870,797	370 877	33,413,052
Imports						
Total salt cake and Glauber's salt						
United Kingdom	19 997	1,199,000	32 828	1,843,000	16 657	1,477,000
United States	524	222,000	588	231,000	845	172,000
Other countries	63	18,000	10	27,000	48	16,000
Total	20 584	1,440,000	33 426	2,101,000	17 550	1,665,000
Exports						
Crude sodium sulphate						
United States	238 707	26,093,000	205 254	23,028,000	220 508	23,646,000
New Zealand	-	-	5 517	524,000	11 984	806,000
Other countries	42	11,000	80	13,000	905	179,000
Total	238 749	26,104,000	210 851	23,565,000	233 397	24,632,000

Sources: Energy, Mines and Resources Canada; Statistics Canada.
P Preliminary; .. Not available; - Nil.

TABLE 2. CANADA, NATURAL SODIUM SULPHATE PLANTS, 1986

	Plant Location	Source Lake	Annual Capacity (tonnes)
Alberta			
Agassiz Resources Ltd.	Metiskow	Metiskow	75 000
Saskatchewan			
Agassiz Resources Ltd.	Grant	Snakehole & Verlo	63 000
Agassiz Resources Ltd.	Hardene	Alsask	42 500
Millar Western Industries Limited	Palo	Whiteshore	109 000
Ormiston Mining and Smelting Co. Ltd.	Ormiston	Horseshoe	90 700
Saskatchewan Minerals	Chaplin	Chaplin	90 000
Saskatchewan Minerals	Fox Valley	Ingebrigt	163 000
Saskatchewan Minerals	Gladmar[1]	East Coteau	45 500
Total			678 700

Source: Company reports.
[1] Closed indefinitely since 1983.

TABLE 3. CANADA, SODIUM SULPHATE PRODUCTION, TRADE AND CONSUMPTION 1970, 1975, AND 1979-86

	Production[1]	Imports[2]	Exports	Consumption
	(tonnes)			
1970	445 017	26 449	108 761	291 439
1975	472 196	22 638	178 182	256 385
1979	443 279	23 156	193 268	255 059
1980	496 000	20 211	245 831	232 045
1981	535 000	24 960	284 281	216 298
1982	547 000	17 293	367 924	191 988
1983	453 939	22 479	265 752	190 625
1984	389 086	20 584	238 749	235 504
1985	366 217	33 426	210 851	241 143
1986	370 877P			

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Producers' shipments of crude sodium sulphate. [2] Includes Glauber's salt and crude salt cake.
P Preliminary.

TABLE 4. CANADA, AVAILABLE DATA ON SODIUM SULPHATE CONSUMPTION, 1983-85

	1983	1984	1985P
	(tonnes)		
Pulp and paper	141 212	192 805[2]	184 652
Soaps	40 219	36 446	47 906
Glass and glass wool	8 558	5 688	7 665
Other products[1]	636	565	920
Total	190 625	235 504	241 143

[1] Colours, pigments, feed supplements and other minor uses. [2] Consumption increase due to increase in number of pulp and paper companies being surveyed.
P Preliminary

TABLE 5. CANADA, RAILWAY TRAIN LOADINGS OF SODIUM SULPHATE, 1983-85

	1983	1984	1985P
	(tonnes)		
Eastern Canada[1]	39 970	56 659	40 470
Western Canada[2]	413 463	377 302	346 498
Total Canada	453 433	433 961	386 968

Source: Statistics Canada.
[1] Eastern Canada refers to provinces east of the Ontario-Manitoba border. [2] Final figure has been adjusted to reflect a recalculation of data.
P Preliminary

TABLE 6. WORLD, SODIUM SULPHATE PRODUCTION

	1976	1977	1978	1979	1980	1981	1982	1983	1984
					(000 tonnes)				
Natural									
Canada	460	395	376	443	481	535	547	454	389
Mexico	250	109	331	361	372	423	128	150	150
Spain	164	181	208	208	156	188	210	312	320
United States	601	577	549	484	529	552	400^{e}	384	395
U.S.S.R.	309	318	330	340	350	350	360	360	360
Other	167	168	147	172	152	131	122	115	155
	1 951	1 748	1 941	2 008	2 040	2 179	1 767^{e}	1 775	1 729
Manufactured	2 510	2 340	3 296	3 495	2 489	2 432	2 284^{e}	2 226	2 232
Total	4 461	4 088	5 237	5 503	4 529	4 611	4 051	4 001	3 961

Sources: Roskill Information Services; EMR for U.S.A. 1982^{e}.
^{e} Estimated.

Sulphur

M.A. BOUCHER

SUMMARY

Preliminary figures indicate that world consumption of elemental sulphur decreased slightly in 1986 compared with 1985. However, consumption was once again greater than world production by 1 to 2 million t. Most of the deficit was filled by re-melting of Canadian stockpiles.

Consumption registered gains in Africa, the U.S.S.R. and Latin America but declined sharply in the United States.

Overall, world production increased slightly over 1985. Production grew in the U.S.S.R., Poland and Saudi Arabia, while it continued to decline in France.

CANADIAN DEVELOPMENTS

Canada's elemental sulphur production in 1986 is estimated at 5.5 to 5.6 million t compared with 5.7 million t in 1985. The decline is the result of lower natural gas production in western Canada.

Preliminary figures indicate that sales also declined to 6.9 million t compared with 8.1 million t the previous year. Lower shipments to the United States, India, China, Brazil and Finland accounted for most of the decrease. Exports to the U.S.S.R., however, increased considerably which may mean an increased demand for phosphate fertilizer production and/or problems associated with sulphur production and developments in the U.S.S.R. Year-end inventories were approximately 8.4 million t.

Petro-Canada's Brazeau sulphur recovery plant, commissioned in August 1985 at a rated capacity of 80 tpd (29 000 tpy), will be expanded to 260 tpd in late-1987 for an annual production capacity of 95 000 t.

Canadian Occidental Petroleum Ltd. started its new 835 tpd sulphur recovery plant at Okotoks in June 1986.

Canterra Energy Ltd. intends to start reclaiming 300 tpd sulphur from its Ram River sulphur block base pad in Spring 1987: capital investment for the project is approximately $4.3 million. The block base pad contains 238 000 t of recoverable sulphur containing 18 to 20 per cent impurities. A cold flotation process developed and tested by Canterra will be used to recover the sulphur.

Shell Canada Limited plans to spend $40 million on a demonstration sulphur-recovery project in the Sundre area, about 130 km northwest of Calgary. Shell, jointly with Mobil Oil Canada Ltd. and Canadian Superior Oil Ltd., plans to process gas with 90 per cent hydrogen sulphide content from two existing wells in the Bearberry region west of Sundre. Construction of a 200 tpd sulphur demonstration plant is expected to commence in 1988 and be completed in 1990. Commercial production may start in the mid-1990s, but the design and capacity of the plant will depend on the results of the demonstration plant. In-place reserves of ultra sour gas in the Bearberry field are estimated at 70 to 100 million t of sulphur. The reserves are in a Leduc Devonian reef at a depth of approximately 4 000 m.

Palmer Ranch Limited, a family-owned Alberta corporation, recently joined Cansulex Limited. Palmer Ranch produces approximately 10 000 tpy of elemental sulphur from six wells in Alberta.

Mobil Oil Canada, Ltd. intends to terminate its membership in Cansulex before the end of 1987. Mobil which owns Canadian Superior wants to consolidate marketing control of its various sulphur resources. Mobil has a production capacity of 150 000 to 200 000 tpy of sulphur while Canadian Superior, which markets its own sulphur, has a production capacity of 70 000 to 75 000 tpy of sulphur.

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WORLD DEVELOPMENTS

During the next ten years, the principal increase in world sulphur production is expected to come from Eastern Europe, especially the U.S.S.R. and Poland.

In the U.S.S.R. new production capacity of recovered sulphur should increase by close to 5 million t during the period 1986-95 as a result of the development of sour natural gas in the regions of Astrakhan and Karazseganak, and oil and gas at Tenguiz. The gas at Astrakhan near the Caspian Sea is particularly sour, containing 24 per cent H_2S and production capacity from Astrakhan could reach 4 million tpy of sulphur by the mid-1990s.

There are two phases of the Astrakhan project and it is expected that the purchases of sulphur by the U.S.S.R. will only change significantly when the first phase of the project will have reached a high operating rate ensuring a steady sulphur production, when the transport system is fully tested and minimum stocks are in place to ensure continuity of supply. Imports should start to decline near 1990. When phase two reaches its normal operating rate, i.e., around the mid-1990s, the U.S.S.R. may decide to export sulphur to earn foreign currency and/or sell sulphur to North African countries in exchange for phosphate rock as the U.S.S.R. is reported to be planning substantial expansions in phosphatic fertilizer production during the 1990s. If phosphatic fertilizer production expands as planned in the U.S.S.R. and in other Eastern European countries, then lower grain exports to the COMECON from Canada, United States, Australia and Western Europe can be expected. This in turn would result in a decline of sulphur requirements in these countries.

Poland is the second largest exporter of elemental sulphur after Canada. Most of the 4.7 to 4.9 million tpy production comes from Frasch mining, but the bulk comes from only two Frasch mines, the Jeziorko and Grzybow mines. About 80 per cent of Polish production is exported, mainly to Eastern Europe, but also to Western Europe. A new Frasch mine at Oziek with an annual capacity of 1.3 million t is under development, and full operation is expected in the early-1990s. The mine is being developed largely as a replacement for the Grzybow mine which has been in operation for nearly 20 years. Production at the Grzybow mine has declined from 1.45 million t in 1980 to about 800 000 t in 1985 and should decrease to about 500 000 t in 1988 as a result of depleting reserves. Polish production is not expected to change significantly until the mid-1990s.

In the United States, one of the world's major Frasch producing country, no new mines are being planned and reserves continue to fall. Unless new deposits are developed, production is expected to decline from 4 to 4.5 million t in 1986 to only about 2 million tpy by the year 2000. However, if market conditions improve and if energy prices, which are a major cost in Frasch mining, remain low, then mothballed domes may be reopened and production could stabilize to around 3 million tpy by the mid-1990s.

Mexico produces annually 1.8 to 1.9 million t of sulphur, of which about 1.5 million t is Frasch. Frasch production is increasing slowly in Mexico as small-scale deposits are being developed, especially the Petapan and Otapan domes. As a result, Frasch production should reach 1.9 to 2 tpy by 1990.

China is reported to be developing two major pyrite mines, the first in the Guandong Province of southern China and the second in outer Mongolia. No detailed information is yet available on reserves and planned production of the mines.

Large natural sulphur deposits are reported to have been discovered in the northern Sinai Peninsula of Egypt. Unconfirmed reports indicate that Frasch mining techniques could be used to develop these deposits which will have a total initial production capacity of 500 000 tpy of sulphur.

PRICES

Contract prices for offshore exports of elemental sulphur from Vancouver were $US 135-139 a tonne for the first half of 1986. During the second half, quoted prices dropped to $US 125-135 a tonne reflecting a reduced demand for sulphur.

Spot prices started the year at $US 135-139 and declined steadily to $US 115-118 a t at the end of the year.

USES

About 60 per cent of all the sulphur consumed in the world is used in the production of fertilizers such as superphosphates, ammonium phosphate, and ammonium sulphate. The second largest consuming sector is the chemical industry where sulphur is used in products ranging from pharmaceuticals to explosives and petroleum catalysts. Other consumers of sulphur include the manufacture of titanium dioxide used in paint, enamels, paper, and ink; iron and steel; and nonferrous metals. These consuming industries use sulphur in the form of sulphuric acid which accounts for almost 90 per cent of total sulphur consumption (60 per cent of sulphuric acid consumption is in fertilizers). Products requiring sulphur in the non-acid form include insecticides and fungicides, pulp and paper, photography, leather processing, rayon, rubber, etc.

OUTLOOK

In the short-term, the tight supply-demand situation that existed in the world sulphur industry in 1986 is expected to continue in 1987 because world consumption should again exceed production as no new major producer is expected to come on-stream. As a result, sulphur inventories in Canada should continue to decline. Ammonia is used in the production of ammonium sulphate and ammonium phosphate fertilizers. The production of ammonia requires large quantities of hydrocarbons and especially, natural gas. So, if sulphur prices remain stable, then low energy prices should stimulate consumption of sulphur in developing countries where most growth in phosphate fertilizer production is expected. In Canada, gas deregulation should help expand exports of natural gas to the United States and consequently increase sulphur production.

In the longer term, large development projects in sulphur production and exports in the U.S.S.R. and Poland may help fill the void left by depleted inventories in Canada. However, important shortages in the world may develop during the 1990s if these projects are delayed and if phosphate mining projects in Morocco, Jordan, Tunisia, U.S.S.R., China, etc. that require sulphur for the production of phosphatic fertilizers are developed as planned.

Consequently, western world countries may have to rely increasingly on the Eastern Bloc for sulphur needed by their fertilizer and chemical industries unless new sulphur deposits (native, volcanic, Frasch, high H_2S gas, pyrites, etc.) are developed in the Western world.

PRICES (end of year)

	1983	1984	1985	1986
		($/t)		
Canadian sulphur prices as quoted in Alberta Energy Resources Industries monthly statistics				
Sulphur, elemental, f.o.b. plant				
North American deliveries	52.64	77.47	109.86	102.20
Offshore deliveries	61.43	113.29	143.63	113.03
Canadian sulphuric acid price as quoted in Corpus Chemical Report				
Sulphuric acid, f.o.b. plants, East, 66° (93%) Be, tanks	104.00	98.80-104.00	108.00	108.00
United States prices, U.S. currency, as quoted in Engineering and Mining Journal				
Sulphur, elemental				
U.S. producers, term contracts f.o.b. vessel at Gulf ports, Louisiana and Texas				
Bright	130.40	130.40	140.20	145.10
Dark	131.40	131.40	139.20	139.20
Export prices, ex terminal Holland				
Bright	130.90-137.80	130.90-137.80	152.50	161.90-164.80
Dark	130.90-137.80	130.90-137.80	152.50	152.50

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f.o.b. Free on board.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
CANADA					
92503-1	Sulphur of all kinds, other than sublimed sulphur, precipitated sulphur and colloidal sulphur	free	free	free	free
92802-1	Sulphur, sublimed or precipitated; colloidal sulphur	free	free	free	free
92807-1	Sulphur dioxide	free	free	free	free
92808-1	Sulphuric acid, oleum	1.9	1.9	25	free
92813-4	Sulphur trioxide	free	free	free	free
MFN Reductions under GATT (effective January 1 of year given)			1986	1987	
			(%)		
92808-1			1.9	free	
UNITED STATES					
418.90	Pyrites		free		
415.45	Sulphur, elemental		free		
416.35	Sulphuric acid		free		
			1986	1987	
			(%)		
422.94	Sulphur dioxide		4.4	4.2	

Sources: The Customs Tariff, 1986 Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated (1986), USITC Publication 1775; U.S. Federal Register, Vol. 44, No. 241.

TABLE 1. CANADA, SULPHUR SHIPMENTS AND TRADE, 1984-86

	1984		1985		1986P	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Shipments						
Pyrite and pyrrhotite[1]						
Gross weight	-	-	-	-	-	-
Sulphur content	-	-	-	-	-	-
Sulphur in smelter gases[2]	844 276	63,200	822 359	86,342	759 593	66,983
Elemental sulphur[3]	8 352 978	609,141	8 102 163	1,026,202	6 867 888	927,083
Total sulphur content	9 197 254	672,341	8 924 522	1,112,544	7 627 481	994,066
Imports						
Sulphur, crude or refined						
United States	3 014	813	3 154	1,079	10 721	2,587
Other countries	5	2	13	4	39	9
Total	3 019	815	3 167	1,083	10 760	2,696
Sulphuric acid, including oleum						
United States	28 317	2,721	17 297	2,075	19 402	2,511
West Germany	3	..	4	..	14	2
Norway	-	-	-	-	-	-
Other countries	10	10	5	1	9 710	573
Total	28,330	2,731	17 306	2,076	29 126	3,086
Exports						
Sulphur in ores (pyrite)						
South Africa	-	-	..	99	..	-
United States	..	34	..	11	..	17
Brazil	-	-	-	-	..	98
Other countries	-	-	-	-	..	22
Total	..	34	..	110	..	137
Sulphuric acid, including oleum						
United States	468 906	15,155	702 940	18,738	755 594	25,236
Other countries	84 874	3,416	41 792	1,778	12	27
Total	553 780	18,570	744 732	20,516	755 606	25,263
Sulphur, crude or refined, nes						
United States	1 781 716	134,006	1 363 596	144,285	610 326	69,927
Brazil	516 757	68,067	620 054	112 237	479 928	91,620
Morocco	346 546	45,363	826 499	154,824	738 967	139,175
Tunisia	288 107	39,408	395 161	75,404	316 914	60,383
South Africa	533 000	64,205	417 822	71,276	318 803	59,249
Australia	422 592	50,837	396 442	68,812	441 914	81,392
South Korea	325 323	39,870	506 357	88,301	425 974	78,069
People's Republic of China	248 666	28,149	162 576	30,016	-	-
U.S.S.R.	180 341	21,666	294 415	51,850	848 080	158,758
Finland	148 243	17,554	177 301	30,159	-	-
India	333 392	49,999	482 583	83,889	243 848	39,356
Israel	258 676	25,643	228 065	27,874	179 796	23,835
Taiwan	226 559	28,614	185 027	33,810	228 653	40,535
Netherlands	178 388	21,206	144 534	26,592	274 957	52,662
France	96 049	12,515	108 334	19,819	89 902	17,068
New Zealand	216 839	26,854	213 788	38,554	77 418	14,272
Other countries[4]	1 225 653	159,234	1 325 826	232,988	981 563	926,301
Total	7 326 847	831,190	7 848 380	1,290,690	6 257 043	1,108,873

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Producers' shipments of by-product pyrite and pyrrhotite from the processing of metallic sulphide ores. [2] Sulphur in liquid SO_2 and H_2SO_4 recovered from the smelting of metallic sulphides and from the roasting of zinc-sulphide concentrates. [3] Producers' shipments of elemental sulphur produced from natural gas; also included are small quantities of sulphur produced in the refining of domestic crude oil and synthetic crude oil. [4] Mainly Belgium-Luxembourg, Italy, Senegal, Indonesia, Argentina, Chile, Cuba, and Mozambique.
P Preliminary; - Nil; .. Not available; nes Not elsewhere specified.

TABLE 2. CANADA, SOUR GAS SULPHUR EXTRACTION PLANTS, 1983, 1985 AND 1986

Operating Company	Source Field or Plant Location	H_2S in Raw Gas	Daily Sulphur Capacity		
			1983	1985	1986
	(Alberta, except where noted)	(%)		(tonnes)	
Amerada Hess Corporation	Olds	13	389	389	389
Amoco Canada Petroleum Company, Ltd.	Bigstone Creek	19	382	382	382
Amoco Canada Petroleum Company Ltd.	East Crossfield	26	1 797	1 797	1 797
Canadian Occidental Petroleum Ltd.	Okotoks	–	–	–	835
Canadian Occidental Petroleum Ltd.	Paddle River	1	19	19	19
Canadian Superior Oil Ltd.	Harmattan-Elkton	56	490	515	515
Canadian Superior Oil Ltd.	Lonepine Creek	12	157	157	157
Canterra Energy Ltd.	Brazeau River	2	42	42	42
Canterra Energy Ltd.	Okotoks	34	431	431	431
Canterra Energy Ltd.	Rainbow Lake	4	139	139	139
Canterra Energy Ltd.	Ram River (Ricinus)	19	4 572	4 572	4 572
Canterra Energy Ltd.	Windfall	8	–	1 199	1 199
Chevron Standard Limited	Kaybob South	20	3 537	3 557	3 557
Chevron Standard Limited	Nevis	7	215	–	–
Chieftain Development Co. Ltd.	Sinclair	5	256	256	256
Dome Petroleum Limited	Steelman, Sask.	1	7	7	7
Esso Resources Canada Limited	Joffre	11	17	17	17
Esso Resources Canada Limited	Quirk Creek	9	293	293	293
Esso Resources Canada Limited	Redwater	4	33	33	33
Gulf Canada Limited	Homeglen-Rimbey	2	333	128	128
Gulf Canada Limited	Nevis	7	297	295	295
Gulf Canada Limited	Pincher Creek	5	159	–	–
Gulf Canada Limited	Strachan	9	943	943	943
Gulf Canada Limited	Hanlan	9	1 092	1 092	1 092
Home Oil Company Limited	Carstairs	1	65	65	65
Hudson's Bay Oil and Gas Company Limited	Brazeau River	1	110	110	110
Hudson's Bay Oil and Gas Company Limited	Caroline	1	8	8	8
Hudson's Bay Oil and Gas Company Limited	Edson	2	284	284	284
Hudson's Bay Oil and Gas Company Limited	Kaybob South (1)	13	1 086	1 086	1 086
Hudson's Bay Oil and Gas Company Limited	Kaybob South (2)	17	1 085	1 086	1 086
Hudson's Bay Oil and Gas Company Limited	Lonepine Creek	10	283	283	283
Hudson's Bay Oil and Gas Company Limited	Sturgeon Lake	12	98	98	98
Hudson's Bay Oil and Gas Company Limited	Zama	8	74	74	74
Mobil Oil Canada, Ltd.	Wimborne	14	182	182	182
Mobil Oil Canada, Ltd.	Teepee	4	30	30	30
PanCanadian Petroleum Limited	Morley	5	18	18	18
Petro-Canada	Brazeau	–	–	80	80
Petro-Canada	Gold Creek	5	43	43	43
Petro-Canada	Wildcat Hills	4	177	177	177
Petrogas Processing Ltd.	Crossfield (Balzac)	14	1 696	1 696	1 696
Saratoga Processing Company Limited	Savannah Creek (Coleman)	20	389	389	389
Shell Canada Limited	Burnt Timber Creek	10	489	489	489
Shell Canada Limited	Innisfail	23	163	163	163
Shell Canada Limited	Jumping Pound	6	566	566	566
Shell Canada Limited	Progress	–	–	25	25
Shell Canada Limited	Rosevear	8	171	171	171
Shell Canada Limited	Simonette River	7	95	95	95
Shell Canada Limited	Waterton	17	3 107	3 148	3 148

TABLE 2. (cont'd)

Operating Company	Source Field or Plant Location (Alberta, except where noted)	H_2S in Raw Gas (%)	Daily Sulphur Capacity 1983	1985	1986
			(tonnes)		
Sulpetro Limited	Minnehik-Buck Lake	1	45	45	45
Suncor Inc.	Rosevear	8	110	110	110
Texaco Exploration Company	Bonnie Glen	-	12.5	12.5	12.5
Westcoast Transmission Company Limited	Fort Nelson, B.C.		1 100	1 100	1 100
Westcoast Transmission Company Limited	Taylor Flats, B.C.	3	460	460	460
Westcoast Transmission Company Limited	Pine River			1 055	1 055
Western Decalta Petroleum Limited	Turner Valley	1	11	11	11

Sources: From Alberta Energy Resources Conservation Board publications; Oil Week, January 1983, 1985 and 1986.
- Nil.

TABLE 3. CANADIAN PETROLEUM REFINERY SULPHUR CAPACITIES, 1983-85

Operating Company	Location	Daily Capacity 1983	1984	1985
		(tonnes)		
Canadian Ultramar Limited	St. Romuald, Quebec	81	81	81
Chevron Canada Limited	Burnaby, British Columbia	10	10	10
Consumers' Co-operative Refineries Limited	Regina, Saskatchewan	-	18	18
Gulf Canada Limited	Edmonton, Alberta	56	56	56
	Port Moody, British Columbia	25	25	25
	Clarkson, Ontario	49	49	49
Husky Oil Ltd.	Prince George, British Columbia	5	5	5
Imperial Oil Limited	Edmonton, Alberta	40	40	40
	Dartmouth, Nova Scotia	76	76	76
	Sarnia, Ontario	100	140	140
	Ioco, British Columbia	20	20	20
Irving Oil Limited	Saint John, New Brunswick	200	200	200
Petro-Canada	Oakville, Ontario	41	41	41
Shell Canada Limited	Sarnia, Ontario	31	31	31
Sulconam Inc.	Montreal, Quebec	300	300	300
Suncor Inc.	Sarnia, Ontario	10	10	10
Texaco Canada Inc.	Nanticoke, Ontario	8	8	8
Total		1 052	1 110	1 110

Sources: Oilweek; Company reports.
- Nil.

TABLE 4. CANADA, PRINCIPAL SULPHUR DIOXIDE AND SULPHURIC ACID PRODUCTION CAPACITIES, 1984[1]

Operating Company	Plant Location	Raw Material	Annual Capacity Liquefied SO_2	 Sulphuric Acid[2]	 Sulphur Equivalent
				(000 tonnes)	
Brunswick Mining and Smelting Corporation Limited	Belledune, New Brunswick	SO_2 lead zinc		160	52
Canadian Electrolytic Zinc Limited	Valleyfield, Quebec	SO_2 zinc conc.		440	144
C-I-L Inc.	Beloeil, Quebec	elem. sulphur		65	21
Falconbridge Limited	Sudbury, Ontario	SO_2 pyrrhotite		355	116
Gaspé Copper Mines, Limited	Murdochville, Quebec	SO_2 copper		160	52
Inco Metals Company	Copper Cliff, Ontario	SO_2 pyrrhotite & nickel conc.		550	180
	Copper Cliff, Ontario	SO_2 copper	82-90	-	45
International Minerals & Chemical Corporation (Canada) Limited[3]	Port Maitland, Ontario	elem. sulphur		250	82
Kidd Creek Mines Ltd.	Kidd Creek, Ontario	SO_2 zinc conc.		440	144
NL Chem Canada, Inc.	Varennes, Quebec	elem. sulphur		56	18
Subtotal, Eastern Canada				2 476	854
Border Chemical Company Limited	Transcona, Manitoba	elem. sulphur		150	49
Cominco Ltd.	Kimberley, British Columbia	SO_2 pyrrhotite		230	75.2
	Kimberley, British Columbia	elem. sulphur		75	24.5
	Trail, British Columbia zinc roaster	zinc conc.		430	140.6
	Trail, British Columbia zinc pressure leach				40
	Trail, British Columbia lead smelter	lead conc.	75		37.5
Eldorado Resources Limited	Rabbit Lake, Saskatchewan	elem. sulphur		45	15
Esso Chemical Canada	Redwater, Alberta	elem. sulphur		965	316
Inland Chemicals Ltd.	Fort Saskatchewan, Alberta	elem. sulphur		136	44
	Prince George, British Columbia	elem. sulphur		35	11
Sherritt Gordon Mines Limited	Fort Saskatchewan, Alberta	elem. sulphur		215	70
Western Co-operative Fertilizers Limited	Calgary, Alberta	elem. sulphur		417	136
Subtotal, Western Canada				2 698	958.8
Total				5 174	1 812.8

Source: Company reports.
[1] 100 per cent H_2SO_4. [2] Plant capacities are related to current production. [3] International Minerals & Chemical Corporation (Canada) Limited discontinued production at Port Maitland in June 1984. Elemental sulphur equivalent of sulphuric acid is 32.7 per cent and sulphur equivalent of liquefied sulphur dioxide is 50 per cent.
- Nil.

TABLE 5. CANADA, SULPHUR SHIPMENTS AND TRADE, 1966, 1970, 1971, 1975 AND 1979-86

	Shipments[1]				Imports	Exports	
	Pyrites	In Smelter Gases	Elemental Sulphur	Total	Elemental Sulphur	Pyrites[2]	Elemental Sulphur
	(tonnes)				(tonnes)	($)	(tonnes)
1966	147 226	453 870	1 851 924	2 453 020	131 955	981,000	1 269 157
1970	159 222	640 360	3 218 973	4 018 555	48 494	1,226,000	2 711 069
1971	140 642	561 046	2 856 796	3 558 484	27 923	1,074,000	2 401 975
1975	10 560	694 666	4 078 780	4 784 006	14 335	170,000	3 284 246
1979	13 964	667 265	6 314 244	6 995 473	1 699	281,000	5 154 831
1980	14 328	894 732	7 655 723	8 564 783	1 767	386,000	6 850 143
1981	5 000	783 000	8 018 000	8 806 000	4 633	109,000	7 309 216
1982	9 000	627 000	6 945 000	7 581 000	2 159	668,000	6 111 444
1983	-	678 286	6 631 123	7 309 409	2 365	77,000	5 670 275
1984	-	844 276	8 352 978	9 197 254	3 019	34,000	7 326 847
1985	-	822 359	8 102 163	8 924 522	3 167	110,000	7 848 380
1986	-	759 593e	6 867 888P	7 627 481			

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] See footnotes for Table 1. [2] Quantities of pyrites exported not available.
P Preliminary; e Estimate; - Nil.

TABLE 6. CANADA, SULPHURIC ACID PRODUCTION, TRADE AND APPARENT CONSUMPTION, 1966, 1970, 1971, 1975, AND 1979-85

	Production	Imports	Exports	Apparent Consumption
		(tonnes - 100% acid)		
1966	2 267 962	6 303	49 848	2 224 417
1970	2 475 070	9 948	129 327	2 355 691
1971	2 660 773	4 492	91 711	2 573 554
1975	2 723 202	154 020	225 402	2 651 820
1979	3 666 080	170 618	139 425	3 697 273
1980	4 295 366	18 048	323 775	3 989 639
1981	4 116 860	82 495	337 518	3 861 837
1982	3 130 854	192 514	259 740	3 063 628
1983	3 686 427	126 573	273 204	3 539 796
1984	4 043 389r	28 330	553 780	3 517 939
1985	3 890 092r	17 306	744 732	3 162 666

Sources: Statistics Canada; Energy, Mines and Resources Canada.
r Revised.

TABLE 7. WORLD PRODUCTION OF SULPHUR, 1982-84

	1982		1983		1984	
	All-forms[1]	Elemental	All-forms	Elemental	All-forms	Elemental
			(000 tonnes)			
World Total	**50,877**	**31,425**	**51,081**	**30,941**	**54,347**	**33,326**
Western World	**32,566**	**22,690**	**32,062**	**21,857**	**34,678**	**23,975**
Western Europe	**7,452**	**3,587**	**7,452**	**3,373**	**7,825**	**3,619**
Finland	470	40	541	48	519	45
France	1,979	1,819	1,970	1,810	1,934	1,751
West Germany	1,771	1,125	1,538	864	1,778	1,129
Italy	493	90	496	106	422	112
Norway	304	8	282	8	275	8
Spain	1,069	20	1,180	20	1,343	20
Sweden	337	22	353	20	387	25
Others	1,029	463	1,092	498	1,167	529
Africa	**896**	**38**	**920**	**60**	**920**	**60**
Asia	**4,431**	**2,472**	**4,414**	**2,427**	**4,841**	**2,862**
Japan	2,740	1,062	2,764	1,074	2,762	1,145
Saudi Arabia	919	919	765	765	830	830
Others	772	490	885	587	1,249	885
Oceania	**195**	**18**	**219**	**35**	**265**	**40**
North America	**16,974**	**14,230**	**16,775**	**14,032**	**18,231**	**15,137**
Canada	6,266	5,616	6,696	5,875	6,663	5,730
United States	10,708	8,614	10,079	8,157	11,568	9,407
Latin America	**2,618**	**2,366**	**2,282**	**1,931**	**2,597**	**2,256**
Mexico	1,990	1,905	1,566	1,481	1,932	1,847
Others	628	461	716	450	665	409
Centrally Planned Economies[2]	**18,312**	**8,735**	**19,019**	**9,084**	**19,669**	**9,352**
Poland	4,994	4,835	5,130	4,960	5,158	4,990
U.S.S.R.	9,132	3,516	9,314	3,737	9,603	4,000
Others	4,186	384	4,575	387	4,908	362

Source: The British Sulphur Corporation Limited, January-February 1986.
[1] All-forms includes elemental sulphur, sulphur contained in pyrites and contained sulphur recovered from metallurgical waste gases, mostly in the form of sulphuric acid. [2] Includes China, North Korea, Vietnam and Cuba.

TABLE 8. CANADA, SULPHURIC ACID CONSUMPTION BY END USE, 1983-85

	1983	1984	1985
		(tonnes)	
Uranium mines	300 236	365 002	338 909
Miscellaneous metal mines	12 111	15 629	19 562r
Crude petroleum and natural gas industry	4 174	8 116	11 983
Sugar, vegetable oil and miscellaneous food processors	837	8 591	5 776
Leather industries	31 424	27 774	20 634
Textile industries			
Pulp and paper mills	290 932	295 374	385 719
Iron and steel mills	6 360	6 209	8 086
Smelting and refining	211 649	198 343	129 921
Electrical products industries	22 230	17 709	19 790
Petroleum refineries and coal products	34 365	29 713	27 950
Fertilizers and other industrial chemicals	2 404 399	2 715 003	2 299 868
Plastics and synthetic resins	5 606	9 439	729
Soap and cleaning compounds	11 544	14 494	11 172
Explosives and miscellaneous chemical industries	38 003	40 680	34 758
Miscellaneous manufacturing industries	10 484	15 905	17 149
Other end uses[1]	31 927	25 592	20 686

Source: Reports from producing companies.
[1] Other end uses include miscellaneous non-metal mines; automotive; hydro, municipal utility and water; metal fabricating; and miscellaneous manufacturing industries.
r Revised; .. Not available.

Talc, Soapstone and Pyrophyllite

M. PRUD'HOMME

SUMMARY

Canadian shipments of talc increased by 9.6 per cent while shipments of pyrophyllite dropped drastically by 23 per cent in 1986. Total shipments rose by 16 per cent in terms of value to $15.7 million. The increase is the result of larger shipments of talc due to new capacity installed by the four producers in Canada. The average unit value of talc rose by 13 per cent.

Reported consumption of talc in 1985 has been estimated at 64 050 t, up by 8.3 per cent reflecting increased demand in paints, pulp and paper, and plastics.

On a nine-month basis in 1986, imports of talc declined by 9.5 per cent in terms of tonnage compared to the same period in 1985. Shipments were mainly into Ontario, British Columbia and Quebec. Average unit value of talc imports in 1986 is estimated at $217 per tonne, an increase of 2.6 per cent from 1985.

During 1986, Bakertalc Inc., in Quebec, completed an expansion program which doubled production capacity for high-grade floated talc. LUZCAN Inc. at St.-Pierre-de-Broughton, Quebec, inaugurated a new processing plant for medium-grade talc products suitable for paints and plastics. Canada Talc Limited carried out development work at the Henderson underground mine to prepare the 215 m level for production. Steetley Talc Inc. completed its 4-year multi-phase expansion to double its capacity of production of high-grade talc for use in paper, paints and cosmetics.

New developments for talc production are in progress in Quebec where International Larder Minerals Inc. has undertaken the rehabilitation of an old underground copper mine to extract talc near Thetford Mines. In British Columbia, Trifco Minerals Ltd. continued the evaluation of its talc property near Quesnel.

During 1986, prices for all grades of talc rose 5 per cent and these are expected to increase similarly in 1987. Talc markets are very competitive in eastern Canada and northeastern United States. Demand for talc in pulp and paper showed a moderate growth in 1986 but plastics offer appreciable growth potential over the next few years.

TALC MINERALS

Talc is a hydrous magnesium metasilicate, $Mg_3Si_4O_{10}(OH)_2$ and is usually intimately associated with numerous other minerals such as serpentine, dolomite and quartz. The colour is characteristically a pale green, grey or creamy white. It exhibits a pearly lustre, a low hardness, a greasy feel and an extreme smoothness. Talc is derived from the alteration of magnesian rocks in an intensive metamorphic environment. It occurs as veinlets, tabular bodies or irregular lenses. Talc is valued for its various properties: extreme whiteness, smoothness, high fusion point, low thermal and electrical conductivity and chemical inertness. Talc is produced in various grades which are usually classified by end-use: paint, ceramic, pharmaceutical and cosmetic.

Steatite (soapstone) is an impure, massive, compact form of talc which can be sawn or machined easily. "Steatite grade" is a special block talc suitable for making ceramic insulators. Soapstone is a mixture of talc, serpentine, chlorite and dolomite, sometimes with small percentages of quartz and calcite. Its durability depends on its chemical inertness and non-absorbency properties. Soapstone has been used since early times in many parts of the world for carving ornaments, pipes, cookware, lamps and other utensils. The art of carving this rock has survived among the Inuit people of Canada up to the present era. Present uses include metalworkers' crayons, refractory bricks, and blocks for sculpturing.

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Pyrophyllite is a hydrous aluminum silicate, $Al_2Si_4O_{10}(OH)_2$, formed by hydrothermal alteration of acid igneous rocks, predominantly lavas which are andesitic to rhyolitic in composition. It occurs in low- and medium-grade metamorphic rocks rich in aluminum. Its physical properties are practically identical to those of talc, and, for this reason, pyrophyllite finds industrial uses similar to talc, notably in ceramic bodies and as a filler in paint, rubber and other products.

PRODUCERS AND DEVELOPMENTS IN CANADA

Talc, soapstone. Talc is produced commercially in two provinces, Quebec and Ontario, while pyrophyllite is produced only in Newfoundland.

Bakertalc Inc. produces talc and soapstone from an underground operation at South Bolton, Quebec, 95 km southeast of Montreal. Talc occurs as dykes and sills, associated with serpentine and magnesite, in Cambrian and Lower Ordovician schists. Ore is extracted at the Van Reet mine and is trucked 16 km south to the company's mill facilities at Highwater. It produces about 12 000 tpy of high quality floated material for use principally in the pulp and paper industry, and a similar tonnage of dry-milled talc used as an industrial filler in paints and plastics. Soapstone is also supplied as sculpture blocks. St-Lawrence Chemical Inc. is the distributor for all Bakertalc's products. By the end of 1986, Bakertalc completed an expansion program which doubled production capacity for high purity talc products suitable for paper and plastics. The introduction of a pebble mill will increase the overall production capacity in excess of 18 000 t. The recovery of tailings has been tested and proven successful at a low rate. The 245 m level was being prepared for further production and exploration work was carried out to increase reserves.

LUZCAN Inc., formerly B.S.Q. Talc Inc., near St.-Pierre-de-Broughton in Quebec, quarries two deposits associated with the Pennington dyke in Leeds and Thetford townships. Occurrences are associated with ultrabasic intrusives, peridotite-serpentinite, in quartz-carbonate-chlorite schists. LUZCAN Inc. produces ground material containing nearly 70 per cent talc, which is used as a filler in joint cement and auto-body compounds and as a dusting agent in asphalt roofing shingles and rubber production. It also supplies soapstone products such as refractory slabs and sculpture blocks. In 1985, Talcs de Luzenac of France acquired a 50 per cent equity in B.S.Q. Talc Inc. to form a new company, LUZCAN Inc. In 1986, LUZCAN Inc. inaugurated a new processing plant with production capacity at about 40 000 t which could be easily expanded to 60 000 t of talc products. An investment of $2 million was used to improve grinding and increase efficiency. As well, operating costs were reduced by automation. LUZCAN Inc. now produces both talc-carbonate and talc-chlorite products having benefitted from the expertise of Talcs de Lusenac in defining new talc grades suitable for paints, flooring and plastics products.

Canada Talc Limited operates an underground mine and also quarries a newly-discovered talc orebody at Madoc, Ontario. The orebodies occur in crystalline dolomite, where tabular hydrothermal replacements have taken place. The talc is of exceptional whiteness but may contain accessory minerals such as sulphides, mica and prismatic tremolite. The company continued its production of dolomite and talc from the new orebodies, west and south of the headframe. In 1986, Canada Talc Limited carried out some development work on its east orebody and completed a decline in the Henderson underground mine to prepare the mining of talc ore at the 215 m level. Canada Talc continued to work on its talc property in Elsevier Township, and to process some lower grades of talc at its Northbrook milling facilities in Kaladar Township.

Steetley Talc Inc., a division of Steetley Industries Limited, produces talc from an open-pit mine in Penhorwood Township, 70 km southwest of Timmins. Talc occurs in talc-magnesite deposits derived from the alteration of ultrabasic volcanic rocks. The ore is processed by flotation and fine-grinding to a high purity, platy material. In 1986, Steetley Talc Inc. completed its expansion program started in 1982 to increase capacity for new grades of talc, to do a feasibility study for production of magnesite and to test new technology for extraction by continuous mining. Plans for further development will be directed toward recovery of talc from tailings. Production capacity increased from 33 000 t to 55 000 t or 64 000 t depending on product mixes. Steetley produces fillers for paints, paper, plastics and rubber, as well as grades for pitch control in the pulp industry and for cosmetics. R.T. Vanderbilt Co. Inc. is the distributor for the American market.

During 1986, the following important developments occurred in Canada:

In Quebec, International Larder Minerals Inc. announced in August, 1986 that development work was to start at the old Harvey Hill copper mine near Thetford Mines. The company will invest $920,000 for rehabilitation of the mine to produce talc from proven reserves estimated at 3.6 million t. The modified processing plant will have a capacity of 40 000 tpy and will produce high quality talc suitable for paints, roofing products, rubber and ceramics for Quebec and eastern Canada markets. International Larder Minerals Inc. was formed in April, 1986 following an amalgamation of Larder Resources Inc. and Flying Cross Resources Ltd., both of Toronto.

In Ontario, Ram Petroleums Limited holds mining leases on a large talc-tremolite deposit near Robertsville. Its subsidiary, Commercial Industrial Minerals Limited, has made some modifications to the milling facilities to enable it to produce a wide range of industrial mineral products but with the main one being a variety of tremolite. Drill-indicated reserves have been estimated at 2 000 000 t of tremolite along with 350 000 t of talc. The deposit is zoned and talc ore could be mined selectively by open-pit. Evaluation and mill tests have been conducted. The option on a deposit of 2 million t of talc owned by Twin Buttes Exploration Inc. was dropped in 1986.

In British Columbia, Trifco Minerals Ltd. continued the evaluation of a talc deposit within serpentinite and serpentinized ultramafic rocks near Quesnel. Exploration work was undertaken along with a preliminary market study and beneficiation of bulk samples. A drilling program indicated several hundred thousand tonnes of material grading 45 per cent talc associated with dolomite, serpentine and chlorite.

In 1986, the CANMET Mineral Processing Laboratory conducted a review of past studies on the concentration of talc from several Canadian deposits with special emphasis on the Highwater talc deposit owned by Bakertalc Inc. Also, an in-house pilot-plant evaluation of talc ore from a Quebec mine is currently under investigation. The first part of this study, completed earlier in 1986, established the basic parameters for selective flotation of talc from ferruginous magnesite. The second will be concerned with establishing optimum grinding parameters which should result in reduced power costs. Currently the ore is ground to 85 per cent minus 325 mesh although liberation is essentially achieved at 100 per cent minus 65 mesh.

For further information on talc R&D, contact P. Andrews at CANMET (tel. 613-992-8794).

Pyrophyllite. Newfoundland Minerals Limited, a subsidiary of American Olean Tile Company, Inc. (a division of National Gypsum Company), mines pyrophyllite from an open-pit operation near Manuels, 19 km southwest of St. John's, Newfoundland. The deposit appears to be a hydrothermal alteration of sheared rhyolite with altered zones associated mainly with extensive fracturing near intrusive granite contacts. Reserves are believed to be sufficient for about 40 years at the present production rate. Mining has been continuous since 1955. Ore is crushed, sized and hand-cobbed at the mine-site prior to trucking a short distance to tidewater. Production capacity varies between 60 000 tpy and 65 000 tpy. High-quality crude ore is shipped to the parent company's ceramic plants in the United States. Some lower grade pyrophyllite has been used in the local manufacture of joint cement, paints and other products. Limited quantities have been exported to western Europe for use in ceramic products. A market study will be undertaken to assess potential for a wide range of export products.

Other known pyrophyllite deposits in Canada include an extensive area of impure pyrophyllite near Stroud's Pond in the southern part of the Burin Peninsula, Newfoundland; deposits in British Columbia, near Ashcroft and on Vancouver Island.

In Quebec, two pyrophyllite deposits were studied. These are located in Carpentier township near Senneterre and, based on work in 1977, reserves were estimated at 1.8 million t grading more than 40 per cent pyrophyllite in schistose rocks. The pyrophyllite minerals occur in association with quartz, pyrite, chloritoid, paragonite, pinite, sillimanite and garnet.

USES AND SPECIFICATIONS

Talc is used mostly in a fine-ground state; soapstone in massive or block form. There are many industrial applications for ground talc, but fewer than a dozen countries use ground talc on a major scale.

In pulp and paper manufacture, softness, chemical inertness, high reflectance, hydrophobic and organophilic properties and the particle shape of talc, are characteristics that permit its use as a pitch-adsorbing agent, as a paper filler and as a coating pigment. For filler usage, maximum particle size should be below 20 microns; however, 40 micron grades are also used. For coating applications, particle size must be below 10 microns and close to 1 micron for pitch control.

The ceramic industry utilizes very finely ground talc to increase the translucence and toughness of the finished product and to aid in promoting crack-free glazing. Talc must be low in iron, manganese and other impurities which would discolour the fired product. Average particle size for most ceramics must range between 6 and 14 microns, with 90-98 per cent of material passing through 325 mesh.

In plastics, talc improves dimensional stability, chemical and heat resistance, impact and tensile strength, and electrical and insulation properties. It is used in thermoplastics and in thermosets, mainly in polypropylene, nylon and polyester. Chemical coupling agents are used to enhance the bond between the talc filler and the resin matrix in plastic materials. Talc must be free of iron impurities and grits, and must be superfine with an average particle size below 8 microns.

In paints, high-quality talc is used as an extender pigment. A low carbonate content, a nearly white colour, a fine particle size with controlled particle size distribution and a specific oil-absorption are important. However, because of the variety of paints, precise technical requirements for talc pigments are agreed on between consumers and suppliers. Paint characteristics influenced by the use of talc as an extender are gloss, adhesion, flow, hardness and hiding power.

Pharmaceutical industries are well-established users of high-purity talc for preparations and cosmetics, relying on its softness, hydrophobic property and chemical inertness. When finely ground, this grade is used as a filler in tablets and as an additive in medical pastes, creams and soaps.

Lower grade talc is used as a dusting agent for asphalt roofing and rubber products, as a filler in drywall sealing compounds, floor tiles, asphalt pipeline enamels, auto-body patching compounds, and as a carrier for insecticides. Other applications for talc include use in cleaning compounds, polishes, electric cable coating, foundry facings, adhesives, linoleum, textiles and in the food industry.

Soapstone has now only very limited use as a refractory brick or block; however with its softness and resistance to heat, it is still used for marking crayons by metalworkers. Also, the ease with which it can be carved makes soapstone an excellent artistic medium.

Pyrophyllite can be ground and used in much the same way as talc. In ceramics, it imparts a very low coefficient of thermal expansion to tiles. It must be graded minus 325 mesh and contain a minimum of quartz and sericite as impurities. Pyrophyllite may also be used in refractories because its expansion on heating tends to counteract the shrinkage of the plastic fraction. This is particularly true for massive pyrophyllite, the compact and homogenous variety, although small amounts of the crystalline or radiating variety may also be used. Foliated or micaceous pyrophyllite is used as a filler and ceramic raw material.

PRODUCTION, CONSUMPTION AND TRADE IN CANADA

In 1986, Canadian production of talc and pyrophyllite remained steady at about 125 000 t; however, the value of production increased 18 per cent. The production of talc increased 9 per cent in terms of volume, but this was offset by reduced output of pyrophyllite which dropped 24 per cent compared to 1985. The increase in talc shipments is largely due to several expansion programs carried out by the four Canadian producers. The total capacity of the industry for talc production increased 120 per cent from 1982 to 1986 to reach 210 000 tpy.

The higher shipments of talc largely resulted from increased output from Quebec (11.1 per cent) and Ontario (10.6 per cent). In 1986, the average unit value of talc increased 13 per cent compared to 1985. Reported Canadian consumption of talc in 1985 was 64 050 t mainly used for pulp and paper (25 per cent), roofing products (25 per cent), paints (10 per cent) gypsum compounds products (9 per cent), and ceramics (7 per cent).

On a nine-month basis, imports of talc decreased 9.5 per cent in terms of tonnage and 2.1 per cent in terms of value. Imports were mainly from the United States (99 per cent), and into Ontario (48 per cent), British Columbia (23 per cent), Quebec (17 per cent) and Alberta (12 per cent). In 1986, the unit value of talc imports increased 2.6 per cent to $217 per tonne.

All Canadian imports of pyrophyllite were from the United States and shipped mainly to Ontario (94 per cent) at an average unit value of $78.34 per tonne.

Canadian exports of talc to the United States account for more than 90 per cent of total talc exports. In 1985, talc exports to the United States increased 20 per cent to about 27 000 t. The average unit value for imported Canadian talc in the United States decreased 13 per cent to $US 145.70 per short ton in 1985. Canadian exports of crude pyrophyllite to the United States were all shipped to Pennsylvania and Mississippi.

WORLD PRODUCTION AND REVIEW

In 1985, world production of talc and pyrophyllite decreased by less than one per cent to 7.53 million t. Japan is the largest producer of pyrophyllite and accounts for 19 per cent of total world production, followed by the United States with 15 per cent, and China with 13 per cent. Production of talc and pyrophyllite in Asia accounts for 56 per cent of world total, followed by North America with 17 per cent, western Europe with 14 per cent, South America with 6 per cent and Australia with 3 per cent.

Australia

Thames Mining NL discovered a high-grade talc deposit at its Livingston property, northwest of Meekatharra in Western Australia. Preliminary drilling indicated potential resources of 1 million t of talc and engineering studies are being carried out. The company purchased the Mount Seabrook Talc deposit from Watalc Pty Ltd. (formerly Tortola Pty Ltd.). Thames Mining NL has also granted Cyprus Industrial Minerals Company the exclusive right to purchase all cosmetic grades of talc from the Mount Seabrook mine which will be commissioned in mid-1987.

Western Mining Corporation Limited acquired Kalgoorlie Southern Gold Mines Ltd. (KSGM) which operated the Three Springs Talc mine in Western Australia. The operation is the largest talc mine in Australia with shipments close to 160 000 tpy. A former partner of KSGM, Western Mining Corporation Limited, acquired the operation as a counterbid to takeover intentions of Oakhill Pty Ltd. which announced plans to obtain all shares of KSGM in late-1985.

Brazil

Mineraçao Matheus Leme Ltd. in Minas Gerais started its 45 000 tpy processing plant for pyrophyllite products suitable for paints and rubber.

United States

Acqui-Tal Inc. and Vermont Talc division of Omya Inc. in Vermont announced a merger and Vermont Talc will process a new finer grade of talc suitable for cosmetics, pharmaceuticals and papers. Talc mined in Chester is shipped to the mill in Johnson.

Cyprus Industrial Minerals Company announced its plan for the construction of an underground talc mine and a 36 000 tpy processing plant near Chester, Vermont. During 1986, Cyprus has closed its Panamint Mine. Also, the company plans to start underground mining at its Beaverhead open-pit mine in Madison County, Montana.

Montana Talc Co., a joint venture between NICOR Minerals Inc. and Meridian Laird and Minerals Co., started-up its $US 12 million talc mine in Gallatan County, Montana. The company expects to produce about 23 000 t during the first year of operation and, eventually, to increase production to 90 700 tpy.

United Catalysts Inc., owned by Süd Chemie of West Germany, purchased Southern Talc Co. of Chatsworth, Georgia. The company will install floatation equipment to expand its product line and to increase productive capacity, currently about 20 000 tpy. Southern Talc Co. was producing low-grade talc for use in ceramics, rubber and insecticide. Following the purchase, United Catalysts closed the Cliff mine and reactivated the underground Earnest mine capable of producing higher grades of talc through selective mining.

Windsor Minerals Inc. announced the development of an open-pit mine in 1986, adjacent to its existing talc operations in Vermont. Windsor Minerals Inc. mines talc at Hammondsville and Rainbow Argonaut.

United Kingdom

A/S Norwegian Talc will install a new milling facility in the United Kingdom near Hartlepool. The grinding plant will receive crude minerals from Norway, and will be operated by Nortalc Milling Ltd.

Yugoslavia

Ro Rudar, of Konjic, in cooperation with the Institute of Cellulose and Paper of Ljubljana, announced plans for the construction of a 120 000 tpy processing plant for pyrophyllite; this deposit will be mined by open-pit method.

INTERNATIONAL TRADE

Compared to many other commodities, talc is considered in the context of a small, specialty market for functional usage dependent on its unique physical properties. Talc is also widely distributed throughout the world and many countries have been developing deposits. These widespread occurrences enjoy limited international trade, except in the case of high-grade materials, where relatively small quantities compete with substitutes. Most international trade takes place within Europe; in the Far East between Japan, the People's Republic of China and Korea; and in North America between Canada and the United States.

In the United States, total production of talc and pyrophyllite increased 13 per cent to 1 150 000 t, valued at $US 28.2 million in 1985. Exports of talc decreased 7 per cent in terms of tonnage and 72 per cent in terms of value; however, talc exports to Canada increased 6 per cent. U.S. imports of talc for domestic consumption increased 5 per cent to 42 530 t. Most was from Canada (63 per cent), Italy (12 per cent) and France (11 per cent). Talc consumption increased 7 per cent to 980 000 t. Principal uses are: ceramics (32 per cent), paint (16 per cent), pulp and paper (14 per cent), roofing (11 per cent), plastics (8 per cent). Pyrophyllite consumption amounted to 1 124 000 t and was mainly used in ceramics (58 per cent), refractories (16 per cent) and insecticides (10 per cent). Decreases in talc consumption occurred in ceramics and paints while roofing and paper registered an increase. United States manufacturers of vinyl flooring products are looking for substitutes in the event that regulations will require a phase-out of asbestos filler. Asphalt roofing producers are also shifting from other fillers such as dolomite and silica to the exclusive use of talc.

Japanese imports of talc decreased 6 per cent to 556 835 t, mainly resulting from a drop in imports from Australia. Major imports were from China with 78 per cent, followed by Australia (3 per cent), the United States (3 per cent) and the Republic of Korea (3 per cent). Japanese exports were 4 792 t, of which 97 per cent traded within the Far East.

In 1984, the United Kingdom imported 67 615 t of talc mainly from Australia (17 per cent), France (13 per cent) and China (12 per cent).

With nearly 30 countries producing talc and with potential for even wider distribution in the future, supplies are expected to be sufficient to meet forecast growth in world demand.

PRICES

Prices for talc vary according to quality, method of processing, specifications and transportation cost. Due to the many industries served, prices are not very sensitive to minor economic fluctuations but are more reactive to markets competition. Prices for pyrophyllite vary between $30-45 per short ton for bulk materials, fob plant. Since 1984, prices for talc have increased steadily by 5 per cent per year. In 1986, prices of all grades of talc rose by an average of 5 per cent, in line with inflation. During 1987, prices for Canadian talc are expected to show the same moderate increase, about 6 per cent depending on grades. However, listed prices and actual prices differ as negotiations occur between producers and consumers.

OUTLOOK

World demand for talc and pyrophyllite is expected to be about 9.6 million t in 1990 and 15.8 million t in 2000 with an average annual growth rate of 5.0 per cent during the 1983-2000 period. Demand for talc minerals in the United States is a forecast 2.2 million t in 2000 by the U.S. Bureau of Mines.

Demand for talc in plastics is expected to grow because of increasing usage for reinforcement filler. The U.S. Bureau of Mines has forecast an annual growth rate of 10 to 12 per cent for the 1983-2000 period. The growth for chemically-modified talc in plastics will be largely dependent on the production of polypropylene plastics. The price for surface-treated talc products is about twice the price for micronized-beneficiated talc in the United States. Talc demand is expected to grow steadily as producers of plastic compounds consume more filler for replacement of resins and other costly pigments.

Increasing consumption of coated paper, along with the unique properties of talc for use in pitch control and for filler purposes, will contribute to a high growth rate of about 7 per cent. In ceramics, paints, insecticides, roofing and rubber products, consumption growth is forecast to be about 3.5 per cent in North America.

High-purity talc and chemically surface-treated talc will be made available to users on a custom basis. Flexibility on product specifications will result in an increasing demand for talc mixes adjusted to customer's requirements. Talc and pyrophyllite are also perceived as adequate substitutes for some asbestos-filled products especially in roofing and flooring materials.

Substitutes for talc are numerous in its major markets; they include nepheline syenite, kaolin and calcium carbonate in paints; pyrophyllite and feldspar in ceramics; mica and calcium carbonate in plastics; kaolin and calcium carbonate in paper. However, talc is still the primary pitch control agent in the pulp and paper industry.

PRICES

Talc; free on board mine, carload lots, containers included unless otherwise specified: $US per short ton.

	1986
New Jersey	
mineral pulp, ground; (bags extra)	18.50-20.50
Vermont	
98% through 325 mesh, bulk	70
99.99% through 325 mesh, dry processed, bags	147
99.99% through 325 mesh, water beneficiated, bags	213-228
New York	
96% through 200 mesh	67-75
98-99.25% through 325 mesh (fluid energy ground)	83-100
100% through 325 mesh (fluid energy ground)	165
California	
Standard	130
Fractionated	37-71
Micronized	150-220
Cosmetic/Steatite	44-65
Georgia	
98% through 200 mesh	50
99% through 325 mesh	60
100% through 325 mesh (fluid energy ground)	100

Source: Engineering and Mining Journal, 1986.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
CANADA					
71100-3	Talc or soapstone	9.9	9.9	25	6.5
29646-1	Talc for use in manufacture of pottery or ceramic tile (expires June 30, 1987)	free	free	25	free
29647-1	Micronized talc, not exceeding 20 microns	free	4.1	25	free
29655-1	Pyrophyllite	free	free	25	free

MFN Reductions under GATT (effective January 1 of year given)		1986	1987
71100-3	Talc or soapstone	9.9	9.2
29647-1	Micronized talc, not exceeding 20 microns	4.1	4.0

UNITED STATES			
523.31	Talc and soapstone, crude and not ground	0.02¢ per lb.	
523.33	Talc and soapstone, ground, washed, powered or pulverized	2.9	2.4
523.35	Talc and soapstone, cut or sawed, or in blanks, crayons, cubes, disks or other forms, per lb.	free	free
523.37	All other, not provided for	4.8	4.8

Sources: The Customs Tariff, 1986, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated 1986, USITC Publication 1775; U.S. Federal Register.

TABLE 1. TALC, SOAPSTONE AND PYROPHYLLITE PRODUCTION, TRADE 1984-86 AND CONSUMPTION 1984 AND 1985

	1984		1985		1986P	
	(tonnes)	($)	(tonnes)	($)	(tonnes)	($)
Production (shipments)						
Talc and soapstone						
Quebec[1]	..	2,388,443	..	3,143,876	..	3,370,000
Ontario[2]	..	7,111,330	..	8,474,604	..	11,068,000
Total	..	9,499,773	..	11,618,480	..	14,438,000
Pyrophyllite						
Newfoundland	..	1,654,406	..	1,733,765	..	1,307,844
Total production	122 992	11,154,182	126 860	13,352,248	125 262	15,745,844
Imports		($000)		($000)		($000)
Talc, incl. micronized						
United States	37 920	7,341	40 213	8,493	38 310	8,298
France	73	21	91	35	295	61
United Kingdom	75	11	49	7	135	17
Italy	0	0	29	3	4	1
Japan	24	3	29	3	0	0
Other	54	4	54	4	1	..
Sub-total, talc	38 117	5,266	40 466	8,565	38 745	8,377
Soapstone, exc. slabs						
United States	50	12	68	10	24	2
Other	0	0	0	0	1	..
Sub-total, soapstone	50	12	68	10	24	3
Pyrophyllite						
United States	650	43	598	45	624	49
Sub-total, pyrophyllite	650	43	598	45	624	49
Total talc, soapstone and pyrophyllite	38 817	7,438	41 132	8,620	39 393	8,429

	1984	1985P
	(tonnes)	
Reported Consumption[3] (ground talc, available data)		
Pulp and paper products	19 707	24 005
Roofing products	14 743	16 640
Paint and varnish	6 628[r]	6 732
Gypsum products	5 545	4 767
Rubber products	3 332	3 676
Ceramic products	3 523	2 575
Toilet preparations	1 613	1 723
Chemicals	988[r]	1 068
Other products[4]	3 110[r]	3 596
Total	59 189[r]	64 774

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Ground talc, soapstone, blocks and crayons. [2] Ground talc. [3] Reported from EMR survey on the consumption of nonmetallic minerals by Canadian manufacturing plants. [4] Fertilizers, adhesives, cleaners, bearings and brake linings, refractories and other miscellaneous uses.
P Preliminary; .. Not available; [r] Revised.

TABLE 2. CANADA, TALC AND PYROPHYLLITE PRODUCTION AND IMPORTS, 1970, 1975, AND 1980-86

	Production[1]	Imports
	(tonnes)	
1970	65 367	29 999
1975	66 029	30 428
1980	91 848	50 774
1981	82 715	30 322
1982	70 523	34 522
1983	97 030	35 406
1984	122 992	38 817
1985	126 860	41 132
1986P	125 265	39 393

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Producers' shipments.

P Preliminary; .. Not available.

TABLE 3. WORLD PRODUCTION OF TALC, SOAPSTONE AND PYROPHYLLITE, 1981-85

	1981	1982	1983	1984r	1985e
			(000 tonnes)		
Japan	1 545	1 492	1 466	1 500	1 430
United States	1 218	1 030	967	1 020	1 150
People's Republic of Chinae	898	952	952	950	990
Republic of Korea	620	991	632	850	700
U.S.S.R.e	500	510	510	520	520
Brazil	503	384	454	410	420
India	367	336	353	420	400
Finland	307	325	318	330	330
France	309	277	285	290	300
Australia	91	152	150	250	250
North Korea	168	168	168	170	170
Italy	163	164	158	140	130
Canada	83	70	97	125	130
Austria	116	117	121	130	130
Norway	33	85	87	100	100
Other countries	303	385	357	370	380
Total	7 224	7 038	7 075	7 575	7 530

Sources: U.S. Bureau of Mines, Talc and Pyrophyllite 1985; Energy, Mines and Resources Canada.

e Estimated; r Revised.

Tin

A. BOURASSA

In 1986, tin prices continued the decline that started at the outset of the tin crisis in October 1985, and fell by over 50 per cent to $3.30/lb. Tin mine production responded to the low prices and the supply-demand balance is expected to show a deficit. This deficit will allow the resorption of some of the tin stock overhang. Tin metal consumption did not respond to lower tin prices and has remained stable over the last two years. The International Tin Agreement will not be renewed at the expiry of the current agreement. UNCTAD will be sponsoring negotiations for the formation of an International Tin Study Group.

CANADIAN DEVELOPMENTS

Rio Algom Limited's new East Kemptville tin mine started commercial production in 1986, reaching full capacity in September. Total tin production for 1986 is estimated at about 2 375 t of tin-in-concentrate, which is shipped to the Capper Pass & Son Ltd. tin smelter in the United Kingdom owned by Rio-Tinto Zinc Corporation PLC.

On November 17, Rio Algom announced a decision to end its financial obligations to the East Kemptville project. Ownership of the mine has since reverted to the consortium of banks that, led by the Bank of America (Canada), had financed the project. The financing was secured by project assets without further recourse to Rio Algom. At the time of writing, the banks had yet to announce a decision on the future of the mine. It is generally believed that the mine will remain in operation. The mine is considered to be among the lower-cost tin producers. Expected higher tin prices when tin markets return to a long-term equilibrium should allow the mine to become profitable.

The East Kemptville orebody is estimated to contain 56 million t grading 0.16 per cent tin, recovered by open-pit mining. Mill capacity is 9 000 tpd. The life expectancy of the mine is projected at 17 years. Planned production capacity is 4 400 tpy of tin-in-concentrate. These numbers are expected to drop somewhat during the latter years of operation.

Tin is also recovered as a byproduct of base-metal mining by Cominco Ltd. at Kimberley, British Columbia. Cominco recovers the tin as tin-lead alloy containing about 8 per cent tin at its Trail, British Columbia smelter and produces small quantities of special high purity tin from imported commercial grade metal.

Tin mineralization is known in various parts of Canada and higher prices in recent years had encouraged exploration. The first major discovery was the East Kemptville deposit, although there are other deposits known across the country. In October 1985, Lac Minerals Ltd. reached an agreement with Billiton Metals Canada Inc. for the exploration of the North Zone tin prospect at the Mount Pleasant property in New Brunswick. It will spend at least $4 million over a 39-month period and pay Billiton $500,000 to acquire the option to earn a 50 per cent interest in the property. Previous drilling has indicated 5.1 million t of potential reserves grading 0.79 per cent tin. This program is now under way.

Canada relies on imports for its tin metal requirements except for small amounts recovered from recycled solders and detinning, and in primary tin-lead alloys production. Consumption has been falling for several years but this trend was reversed in 1984 when imports grew by almost 20 per cent. Increased consumption was especially noteworthy in tin plate produced by two large Canadian steelmakers, Stelco Inc. and Dofasco Inc. Consumption dropped slightly in 1985.

WORLD DEVELOPMENTS

Since 1973, world tin consumption has trended downward because of substitution away from tin in some end uses, and techno-

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logical developments that have decreased the quantities of tin required in the making of some tin products. This trend was reversed in 1984, mostly as a result of the worldwide economic recovery, but structural factors that caused the previous decline are still present. However, consumption may now stabilize around present levels due to the growth potential of some tin uses and lower future tin prices which should reduce pressure for substituting away from tin.

As can be seen from Table 4, very low tin prices in 1986 have not had an identifiable impact on overall tin consumption.

Low tin prices have brought about major mine production cutbacks in several countries. These cuts were especially severe in Malaysia, Bolivia and Thailand. On the other hand, some producers including Australia, Indonesia, Brazil and Peru were able to show production increases. It should be recalled that most tin producing countries were adhering to export limits imposed under the International Tin Agreement, and that these limits expired in March 1986. Table 5 is based on estimates from the International Tin Council. The latest available information appears to suggest that production has exceeded these projections, especially in the last quarter of the year when tin prices showed some improvement. It is therefore expected that tin-in-concentrate production in 1986 may be closer to 141 000 t than the 137 183 t estimated by the ITC. Brazil is believed to have produced about 27 000 t, Thailand may have exceeded 17 000 t, Peru may have reached 4 400 t and Indonesia 24 490 t.

Overall production levels in 1987 could be somewhat higher if the price does not exceed $4.50/lb. and substantially higher (5 to 10 000 t more) if it does. This would result in a very slow resorption of the stock overhang.

Statistics in the accompanying tables do not include information on most centrally planned countries. Leading producers among these countries include the U.S.S.R. and the People's Republic of China, for which the United States Bureau of Mines estimates production at 23 000 t and 15 000 t, respectively. The Democratic Republic of Germany is estimated to have produced 1 800 t. Tin from these countries is generally consumed domestically, although China is a net exporter to the west (estimated at 4 000 t in 1986). The combined net imports of the U.S.S.R. and East Germany from the west are estimated at over 14 400 t in 1986.

The removal of export controls by the ITC, efforts by governments to reduce and in some cases eliminate taxes and royalties on tin mine production and low tin prices, have brought a marked decline in concentrate smuggling. Tin smuggling in South East Asia had become a major factor, accounting for about 7 per cent of total production or 11 000 t in 1985. While a precise figure on annual smuggling can hardly be established, it is now assumed not to exceed 2 000 t.

The United States General Services Administration (GSA) continued sales of tin from the strategic stockpile. Sales in 1986 totalled 5 490 t. The goal for the United States strategic stockpile is 42 700 t, compared to about 180 000 t at the end of 1986. Although GSA sales represent only a small percentage of the total market, producers believe that they contribute to downward pressure on prices, especially under the current unfavourable circumstances. Sales for 1987 are forecasted at about the same level as in 1986.

Australia increased its tin mine production to over 8 000 t in 1986. This was mainly a result of a major production increase at the Renison Ltd. tin mine in Tasmania which produced over 3 600 t versus 2 547 t in 1985. Aberfoyle Limited's two tin mines, Ardlethan and Cleveland, are now closed. Greenbushes Tin Ltd. has shifted to higher grades of ore in the face of lower prices and has maintained production at 344 t. That production may double in 1987 when production starts from the hard-rock tin tantalite orebody. A government assistance program for tin miners has been set-up but only very small operations are eligible. Total Australian production is expected to drop to about 7 000 t in 1987 following Aberfoyle's closures.

Only a handful of small Bolivian mines are still operating profitably at current tin prices. State owned Corporacion Minera de Bolivia (Comibol), the largest tin producer, has trimmed over half of its work force which numbered 27,000 a year ago, but its production costs are still well above prevailing prices. The biggest production losses in 1986 have been experienced by Comibol, and some medium-sized private mines in fact increased production. Bolivia's production could decrease even further in 1987, perhaps below 10 000 t.

Brazilian tin mine production reached 27 000 t in 1986, despite the closure of some mining sites in Rondonia due to prevailing low tin prices. The shortfall of smaller mines was more than offset by production increases by the largest tin producer, Paranapanema SA, which now produces well over 10 000 tpy. The country's second largest tin producer is Brascan Recursos Naturais S.A. (BRN), a joint venture by Brascan Limited of Canada and British Petroleum Limited. Production from its present 11 working sites is estimated at about 4 000 t. The third largest producer, Empresas Brumadinho, produced about 2 000 t.

The rate of new investments is now slowing down in Brazil. Most new investments in Rondonia are directed at improved productivity, not increased production. However about $US 5 million in investments are earmarked for development in the state of Mapuera. Brazil so far has refused to join the Association of Tin Producing Countries (ATPC) but appears ready to cooperate with the Association's efforts to improve tin prices. Production in 1987 is projected at 26 000 as further closures are expected in the state of Rondonia.

A 40 per cent devaluation of the Indonesian Rupiah helped the country's tin industry face the lower tin prices. In fact the industry was able to increase tin mine production from 21 758 t to 24 490 t in 1986. That number is in excess of the 23 500 t estimate of the ITC. It is reported that the country's largest company, state owned P.T. Tambang Timah, was able to reduce its production costs to the $US 6,000/t level and show a profit for 1986. P.T. Tambang Timah produces about 85 per cent of the country's tin concentrates. The country's production target for 1987 is 27 000 t.

Malaysia's mine production of tin fell considerably to 28 805 t in 1986, from 36 884 t in 1985. Malaysia's tin industry was particularly hard hit by the price slump. According to the government, the country had 175 tin mines employing 12,500 workers at the end of June 1986. That compared with nearly 250 mines and 16,000 workers at the end of January 1986, and 460 mines and 23,000 workers before the tin crisis. The government has taken measures to alleviate some of the hardship. Electricity rates were reduced and a soft loan scheme was established to tide miners over until a price rise to $10.00 Malaysian/kg, or about $4.40/lb. Tin trading on the Kuala Lumpur tin market resumed on February 3 after being suspended on October 25, 1985. In December, Malaysia announced that, starting January 5, 1987, tin from Indonesia and Thailand could be traded at the KLTM.

Thailand's tin mining industry has probably been affected by the lower tin prices more than numbers appear to show. While officials from the Thai government have announced that tin mine production has been maintained at about 17 000 t over the last two years, it is generally agreed that most of the smuggled tin which for years, found its way mostly to Singapore, originated in Thailand. Smuggled tin in 1985 probably exceeded 11 000 t while it is estimated not to have exceeded 2 000 t in 1986. Much of that drop was probably from Thailand. In July, 313 licensed tin mines were operating compared to 633 a year earlier. The suction boat fleet which produces about 2 290 t of the country's tin is down to about 100 boats from 3,000 in the late-1970s. Thailand's production is expected to fall further in 1987, perhaps to as low as 14 000 t if prices stay at current levels. It is suggested that 1986 production figures include some stock run-down by miners and that real new production in 1986 may not have exceeded 15 000 t. The government has taken several measures to assist its tin industry after the October tin crisis, including reduced royalty fees, the repeal of a tin special fee and reduced business and municipal taxes.

INTERNATIONAL ORGANIZATIONS

The International Tin Agreement

Tin is the only metal for which there is an agreement involving producing and consuming countries that contains economic provisions for market stabilization. Successive five-year pacts have been in force since 1956. The Sixth International Tin Agreement entered provisionally into force on July 1, 1982, to replace the Fifth Agreement. Provision is made in the agreements for market stabilization measures, including purchases and sales under a buffer stock arrangement, and the implementation of export controls on producing members if buffer stock operations are insufficient to protect the floor price.

Upon its entry into force, countries that had either signed or ratified the Sixth Agreement included six producers (Australia, Indonesia, Malaysia, Nigeria, Thailand and Zaire), which together accounted for 70 per cent of reported 1982 world tin mine production, and 18 consuming members, including Canada, which together accounted for 51 per cent of 1982 world tin consumption. Leading members of the Fifth Agreement that did not join the Sixth were the United States, U.S.S.R. and Bolivia.

Association of Tin Producing Countries

The Association was officially formed on August 13, 1983, after lengthy negotiations. It had five members: Bolivia, Malaysia, Indonesia, Thailand and Zaire. Nigeria joined on August 31 and Australia in November of the same year. These seven participating members now account for about 75 per cent of non-communist world tin production. The Association's head office is in Kuala Lumpur, Malaysia.

The main objectives proposed by the Association are the promotion of tin use through research and technological development, support of the Sixth ITA's market stabilization activities and an increase in the economic spinoffs from tin production in the economies of member countries.

The Association works closely with the International Tin Research Council in London, England and the South East Asia Tin Research and Development Centre, in Malaysia. Both of these organizations are already financed by these same tin producers.

Research Organizations

The International Tin Research Council is entrusted with the task of maintaining and extending the use and effectiveness of tin in modern technology. It is financed by the governments of six of the major tin producing countries, Bolivia, Indonesia, Malaysia, Nigeria, Thailand and Zaire.

The Council's headquarters and laboratories are the International Tin Research Institute in Greenford, Middlesex, England. The Council also has organizations for information, service and technical development in several major tin consumer and producer countries.

The South East Asia Tin Research and Development (SEATRAD) Centre is a regional organization established by the governments of Indonesia, Malaysia and Thailand, with assistance from the Economic and Social Commission for Asia and the Pacific (ECAP) and other United Nations agencies. The purpose of the Centre is to promote, conduct and coordinate research and training in relation to the technical and economic aspects of exploration, mining, mineral processing and smelting of tin. The Centre's headquarters and laboratories are located in Ipoh, Malaysia. In addition to the work being conducted in the laboratory, field projects are maintained in various member countries in southeast Asia.

The Centre is financed by equal contributions from member countries.

International Tin Study Group

After members of the International Tin Council announced that they would not seek a Seventh International Tin Agreement, tin producing and consuming countries met in Geneva in November, under the sponsorship of UNCTAD, to see whether there was sufficient interest in continued consumer-producer cooperation on tin. The response from participants was generally favourable to continued cooperation through an international Tin Study Group. UNCTAD is now preparing for a first negotiating meeting for the formation of such a study group. The meeting should take place in Geneva some time in 1987.

It is expected that the study group will be modelled on the International Nickel Study Group. It will be totally separate from the International Tin Council and will have no market intervention powers. Its purpose will be to enhance tin market transparency through comprehensive statistical data collection and dissemination and through appropriate market studies.

TIN PRICES AND STOCKS

Shortly after it became clear in March 1986 that a negotiated settlement could not be reached to end the tin crisis, tin prices fell to $Cdn 3.30/lb where they stayed for much of the year. In October, however, prices showed some strength and closed the year at $4.20/lb. This was an unexpected improvement given poor market fundamentals. The price strength resulted from discipline by several producers refusing to sell substantial amounts of concentrate at low prices and by bankers and other holders of tin stocks withholding stocks from the market.

There is a risk that, if prices were allowed to rise much over [illegible].50/lb, tin mine production could rebound and postpone the return to a long-term market equilibrium. The decision by ATPC member countries to set quotas is probably an effort to reassure markets that such an increase would not occur. Unfortunately, Southeast Asian producing countries have a poor record of effectively enforcing quotas and preventing smuggling when economics encourage increasing production.

Stocks of tin metal were estimated at about 100 000 t at the beginning of the year while stocks of tin-in-concentrate were estimated at somewhat less than 25 000 t.

Tin metal supply for 1986 included 144 500 t of primary tin metal, 4 000 t of tin metal exports for China and 5 490 t of metal from the GSA in the United States. Tin metal consumption estimated 159 000 t for the western world, plus 14 400 t imported by the U.S.S.R. and the GDR. The difference between these supply and demand figures shows a 20 000 t deficit. Tin metal stocks are expected to have totalled 80 000 t at the end of 1986. Stocks of tin-in-concentrate likely had fallen below 20 000 t.

The disposal of 20 331 t of tin in the GSA stockpile was authorized effective October 1, 1984. As of the end of 1986, the stockpile is estimated to be just below 180 000 t with over 10 000 t still available for disposal under the latest authorization. The stockpile objective is set at 42 700 t, which leaves another 126 181 t surplus to this objective.

USES

Tinplate traditionally has been the largest use of tin worldwide. However, falling tinplate demand in the developed world has more than offset gains in developing countries. Rising tinplate production in the developing countries is curtailing imports from developed countries. In the latter, competition from substitutes in the food and beverage market as well as thinner tin coatings have brought about the decline in the consumption for tinplate. In the United States, aluminum has taken over the large beverage container market. Similarly, the increasing popularity of the microwave oven has food producers looking at alternate packaging material like plastics and cellulose. Tinplate competition also comes from non-tin coated steels, tin-free steel (TFS) or electrolytic chromium coated steel (ECCS).

Solder is another traditional use of tin and in the United States and Japan, it now surpasses tinplate as the largest tin user. Strong growth in the electronics industry has provided a new impetus for this tin use. Growth in tin solder is however limited by the trend towards the use of less and less solder per assembly. This trend is more evident in the increasing use of surface mounted components which permits greater solder savings. A growing regulatory trend in North America to replace the standard lead-tin solder for water pipes with silver-tin solder would increase tin consumption in solder, since the latter uses 95 per cent tin vs 50 per cent in the former.

Chemicals have been the fastest growing newer use for tin. Tin is used in an array of inorganic and organic chemicals, with applications as P.V.C. stabilizers, agricultural pesticides, anti-fouling paints for ships and biocidal compounds for the protection of materials such as paints, textiles and building materials.

Tin is also used for tinning (which includes electronic uses, hot dipping and electroplating in the electronics industry) in bronze, brass and other tin containing alloys; these products are used in construction, machining and equipment and consumer durables.

Consumption of tin in tinplate is estimated at about 50 000 t in 1986. Tin in solder is estimated at 49 000 t. Given the uncertainty surrounding all such estimates, both uses are now more or less of equal importance for tin consumption. Solder is however expected to hold its own in the years to come while tinplate should continue its gradual fall as tinplate continues to lose market share to other packaging materials. Demand for tin in chemicals reached about 21 000 t in 1986 and will keep increasing.

Most of the other traditional uses for tin, excluding tinning which is still growing, should either be stable or show a slight decline. Newer promising uses also include tin in cast iron and tin in powder metallurgy. Overall tin consumption in 1986 is estimated at 159 800 t and, in spite of lower tin prices, shows no sign of improvement. It appears that losses in traditional uses can at best be compensated by gains in new uses.

OUTLOOK

If tin prices do not significantly exceed $Cdn 4.50/lb in 1987, tin mine production is unlikely to increase and should remain at the same level as in 1986, perhaps even lower. Early-1986 production levels were somewhat higher than in the second part of 1986 due to higher prices. This would allow a further decrease in tin stocks and may allow a return to a long-term market equilibrium before the end of this decade. A tin price increase much beyond $4.50 could overly stimulate production, postpone the return to a long-term market equilibrium and bring another later drop in tin prices.

Lower tin prices are not likely to bring major changes in tin consumption, as tin consumption is rather price inelastic. Tin is not a major cost component of tinplate. Solder is not a major cost component of electronic parts. Lower prices will however remove some of the pressure for substituting tin in some of its uses but continuing market adjustments will maintain uncertainty as to future tin prices and availability.

Tin metal consumption is likely to remain more or less stable to the end of the decade. Losses in tin plate will be compensated by gains in other uses, especially chemicals.

A long-term equilibrium price for tin is likely to be about $5.50/lb in 1986 dollars.

TARIFFS

Item No.		British Preferential	Most Favoured Nation (%)	General	General Preferential
CANADA					
	Metals, and manufactures:				
32900-1	Tin in ores and concentrates, n.o.p.	free	free	free	free
	Natural oxides, n.o.p., not including ores of metals:				
33507-1	Tin oxides	free	12.8	25.0	free
33910-1	Collapsible tubes of tin or lead coated with tin	10.0	11.1	30.0	free
34200-1	Phosphor tin in blocks, bars, plates, sheets, strips, rods and wire	5.0	5.8	10.0	3.5
34300-1	Tin, in blocks, pigs, bars or granular form	free	free	free	free
34400-1	Tin strip waste and tin foil:	free	free	free	free
	Sheet or strip of iron or steel, corrugated whether or not with a corrugated or other roll-formed profile, and whether or not with rolled surface pattern/cold-rolled or cold-drawn				
38203-1	Coated with tin or vitreous enamel	8.8	8.8	25.0	5.5
43220-1	Manufactures of tin plate, painted, japanned, decorated or not, and manufactures of tin, n.o.p.	11.1	11.1	30.0	7.0

MFN: Reductions under GATT (effective January 1 or year given)	1986	1987
33507-1	12.8	12.5
33910-1	11.1	10.2
34200-1	5.8	5.5
28203-1	8.8	8.0
43220-1	11.1	10.2

UNITED STATES (MFN)

		1986	1987
	Metal bearing ores and the dross or residuum from burnt pyrites:		
601.48	Tin ore and black oxide of tin	free	
	Unwrought tin:		
622.02	Tin other than alloys of tin	free	
622.04	Alloys of tin	free	
622.06	Other	free	
622.10	Tin waste and scraps	free	
	Plates, sheets and strips, all the foregoing which are wrought, of tin, whether or not cut, pressed or stamped to nonrectangular shapes:		
622.15	Not clad	2.9	2.4
622.17	Clad	5.7	4.8
	Tin wire:		
622.20	Not coated or plated with metal	2.4	2.4
622.22	Coated or plated with metal	4.4	4.2
622.25	Bars, rods, angles, shapes and sections, all the foregoing which are wrought, of tin	4.4	4.2
622.35	Tin powder and flakes	4.4	4.2
622.40	Pipes, tubes and blanks therefor, pipe and tube fittings, all the foregoing of tin:	2.9	2.4
	Base metal foil (whether or not embossed, cut to shape, perforated, etched, etc.) not backed and not cut to shape:		
644.15	Tin foil	8.3	7.0

Sources: The Customs Tariff, 1986, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated 1986, USITC Publication 1775; U.S. Federal Register, Vol. 44, No. 241.

TABLE 1. CANADA, TIN PRODUCTION, IMPORTS AND CONSUMPTION, 1984-86

	1984		1985		1986P	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Production						
Tin content of tin concentrates and lead-tin alloys	209	3,761	119	1,893	2 485	22,077
Imports					(Jan.-Sept.)	
Blocks, pigs, bars						
United States	1 501	23,747	1 074	17,273	1 327	13,460
Brazil	913	14,874	1 401	22,632	649	6,842
Bolivia	428	6,963	430	7,068	506	4,626
Netherlands	520	8,518	60	945	100	808
Singapore	480	7,960	460	7,556	0	0
Other countries	263	3,005	261	3,837	379	3,295
Total	4 105	65,067	3 696	59,311	2 961	29,031
Tinplate						
United States	2 159	1,973	481	579	4 252	4,700
Spain	-	-	-	-	50	33
Greenland	-	-	-	-	17	17
West Germany	-	-	54	34	-	-
United Kingdom	1	1	-	-	2	2
Total	2 160	1,974	535	613	4 321	4,752
Tin, fabricated materials, nes						
United States	267	1,382	304	1,363	242	1,307
West Germany	2	17	8	46	8	21
United Kingdom	19	105	14	107	4	24
Other countries	18	32	22	31	11	61
Total	296	1,544	330	1,547	265	1,413
Exports						
Tin in ores, concentrates and scrap[1]						
United Kingdom	287	1,821	100	292	1 055	7,928
United States	28	149	102	619	1 884	407
Spain	-	-	-	-	77	662
Other countries	-	-	156	930	-	-
Total	315	1,973	358	1,841	3 016	8,997
Tinplate scrap						
United States	3 299	180	3 326	390	367	82
Indonesia	-	-	-	-	-	-
Italy	-	-	-	-	-	-
Taiwan	36	9	-	-	-	-
Other countries	-	-	64	13	102	24
Total	3 335	189	3 379	403	469	106
Consumption						
Tinplate and tinning	2 503	..	2 492	..		
Solder	1 128	..	1 029	..		
Babbit	212	..	151	..		
Bronze	155	..	150	..		
Other uses (including collapsible containers, foil, etc.)	78	..	86	..		
Total	4 076	..	3 908	..		

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Tin content of ores and concentrates plus gross weight of tin scrap.

P Preliminary; .. Not available; - Nil; nes Not elsewhere specified.

TABLE 2. CANADA, TIN PRODUCTION, EXPORTS, IMPORTS AND CONSUMPTION, 1970, 1975 AND 1980-86

	Production[1]	Exports[2]	Imports[3]	Consumption[4]
		(tonnes)		
1970	120	268	5 111	4 565
1975	319	1 052	4 487	4 315
1980	243	883^{r}	4 527	4 517
1981	239	513	3 791	3 766
1982	135	601	3 235	3 528
1983	140	371	3 769	3 371
1984	209	315	4 105	4 076
1985	119	358	3 696	3 908
1986P	2 485	3 016[5]	2 961[5]	

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Tin content of tin concentrates shipped plus tin content of lead-tin alloys produced. [2] Tin in ores and concentrates and tin scrap, and re-exported primary tin. [3] Tin metal. [4] Current coverage exceeds 90 per cent, whereas until 1972, coverage was in the order of 80 to 85 per cent. [5] Jan.-Sept. only.
P Preliminary; ^{r} Revised.

TABLE 3. WORLD[1] TIN PRODUCTION, CONSUMPTION AND PRICES, 1970-86

	Production			Prices	
	Tin in Conc.	Primary Metal	Consumption	Malaysia[2]	NY Dealer[3]
			(000 t)		
1970	185	185	185	10.99	1.74
1971	188	187	189	10.44	1.67
1972	196	191	192	10.36	1.77
1973	189	188	215	11.35	2.27
1974	184	182	200	18.79	3.96
1975	181	179	173	15.94	3.40
1976	180	183	194	18.96	3.49
1977	188	180	185	26.26	4.99
1978	197	194	185	28.82	5.87
1979	200	201	186	32.42	7.11
1980	201	198	174	35.72	7.73
1981	205	197	163	32.34	6.48
1982	190	180	157	30.09	5.86
1983	172	159	155	30.19	6.01
1984	167	161	165	29.16	5.67
1985	158	155	160	29.69	5.25
1986^{e}	137	145	160	15.49	2.94

Source: International Tin Council.
[1] Excludes countries with centrally planned economies, except Bulgaria, Czechoslovakia, Hungary, Poland, Romania and Yugoslavia. [2] Cash price ex-smelter for Grade A tin, shipment within 60 days, in Malaysian ringgits per kg, the ringgit being the unit used to define price levels under successive International Tin Agreements. [3] Metals Week.
^{e} Estimate.

TABLE 4. WORLD[1] CONSUMPTION OF PRIMARY[2] TIN, 1970 AND 1983-86

	1970	1983	1984	1985	1986^e
			(tonnes)		
EEC, total[3]	58 246	38 214	40 710	38 285	39 384
West Germany	14 062	13 792	15 591	15 668	15 660
France	10 500	7 564	7 799	6 900	7 229
United Kingdom	16 951	6 123	5 838	6 000	6 000
Netherlands	5 467	4 400	4 842	4 253	4 720
Italy	7 200	4 200	4 500	5 000	4 300
Belgium/Luxembourg	3 000	1 804	1 697	920	1 270
United States	53 807	34 300	37 819	37 136	37 500
Japan	24 710	30 504	33 275	31 594	30 946
Spain	3 040	4 400	3 900	3 100	3 100
Poland	..	4 351	3 634	3 029	3 206
Brazil	2 139	3 942	4 271	4 644	4 456
Canada	4 640	3 776	4 106	3 781	3 600
Czechoslovakia	3 420	3 550	3 000	2 800	2 800
Republic of Korea	394	2 528	3 632	2 600	2 600
Australia	3 837	2 500	2 600	2 600	2 460
Total, incl. Others	184 800	154 700	164 800	159 600	159 800

Source: International Tin Council.

[1] Excludes countries with centrally planned economies, except Bulgaria, Czechoslovakia, Hungary, Poland, Romania and Yugoslavia. [2] May include secondary tin in some countries.
[3] Includes all 1982 members in all years except Greece in 1970.
.. Not available; ^{e} Estimate.

TABLE 5. WORLD[1] PRODUCTION OF TIN-IN-CONCENTRATES, 1970 AND 1983-86

	1970	1983	1984	1985	1986^e
			(tonnes)		
Malaysia	73 794	41 367	41 307	36 884	28 805
Indonesia	19 092	26 554	23 223	21 758	23 580
Bolivia	30 100	24 736	19 911	16 136	10 990
Thailand	21 779	19 942	21 607	16 593	15 100
Brazil	3 610	13 083	19 957	26 514	25 833
Australia	8 828	9 578	7 922	6 934	8 110
United Kingdom	1 722	4 067	5 047	5 200	4 345
South Africa	1 986	2 668	2 301	2 193	2 104
Peru	20	2 200	2 991	3 807	4 000
Zaire	6 458	2 004	2 410	2 177	1 889
Total, incl. Others	184 900	171 700	167 400	158 200	137 183

Source: International Tin Council.

[1] Excludes countries with centrally planned economies, except Czechoslovakia, Poland and Hungary.
^{e} Estimate.

TABLE 6. WORLD[1] PRODUCTION OF PRIMARY TIN METAL, 1970 AND 1983-86

	1970	1983	1984	1985	1986e
			(tonnes)		
Malaysia	91 945	53 338	46 911	45 500	43 044
Indonesia	5 190	28 390	22 467	20 418	22 475
Thailand	22 040	18 467	19 729	17 996	16 000
Bolivia	300	14 293	15 842	11 400	9 026P
Brazil	3 100	12 560	18 877	24 703	24 587
United Kingdom	22 035	6 498	7 105	7 548	8 705
Netherlands	5 937	3 650	6 188	5 308	5 698
Australia	5 211	2 878	2 687	1 421	1 421
Spain	3 908	2 783	3 426	3 291	2 421
United States	4 540	2 500	4 000	3 000	2 000
South Africa	1 491	2 200	2 200	2 056	1 865
Singapore	..	1 800	3 500	5 308	5 698
Nigeria	8 069	1 400	1 253	1 027	800
Total, incl. Others	184 900	158 800	161 200	155 400	144 500

Sources: International Tin Council.

[1] Excludes countries with centrally planned economies, except Czechoslovakia, Poland and Hungary.

.. Not available; ^{e} Estimate; ^{P} Preliminary.

TABLE 7. MONTHLY AVERAGE TIN PRICES[1], 1985 AND 1986

	Dealer NY U.S. ¢/lb		Malaysia $M/kilogram	
	1985	1986	1985	1986
January	508.14	369.29	29.15	..
February	502.89	433.68	29.15	19.56
March	526.62	318.57	29.16	18.40
April	548.41	270.05	29.21	14.69
May	545.95	256.62	28.86	14.22
June	559.75	256.48	29.56	14.09
July	581.04	255.41	30.76	14.23
August	580.09	255.60	30.74	14.09
September	558.50	258.31	30.18	14.11
October	538.23	267.80	29.91	14.53
November	449.21	287.61	..	15.90
December	411.90	300.00	..	16.68
Yearly average	525.90	294.12	29.66	15.49

Sources: Metals Week; International Tin Council.

[1] Prices are for Grade A (in the United States) or High Grade - 99.85 per cent tin or more -

.. Trading suspended.

Titanium and Titanium Dioxide

D.E.C. KING

SUMMARY

The strong worldwide demand for titanium raw materials and titanium dioxide pigments which began in 1984 continued throughout 1985 and 1986, with producers everywhere operating at or near full capacity in attempting to satisfy the demand.

QIT-Fer et Titane Inc. (QIT) increased the production capacity of its mine and smelter in Canada to over 900 000 t of 80 per cent TiO_2 slag in 1986, and it is slated to reach just over a million tonnes of slag by mid-1988. In 1986, both Canadian pigment producers were operating at their full capacity of about 36 000 tpy of TiO_2 pigment each.

CANADA

Canadian titanium-based industries include ilmenite mining and smelting, titanium oxide and pigment production, titanium metal fabrication to finished parts, coating of welding rods, and the manufacture of titanium carbide and nitride coated parts. Also, titanium-bearing master alloys are incorporated into special steel and aluminum alloys. The mining, smelting and pigment operations are carried out exclusively in Quebec, whereas the downstream activities are located in several provinces. Canada does not have any capacity for producing primary titanium (in the form of sponge or granules) or ferrotitanium. Capacity for vacuum melting of primary titanium to produce billets exists at Eldorado Nuclear Limited, Port Hope, Ontario and facilities to custom forge and roll billets are at Atlas Steels, division of Rio Algom Limited at Welland, Ontario.

QIT-Fer et Titane Inc. (QIT) is the only company that mines titanium ore in Canada. Ilmenite, a mineral containing somewhat more iron than titanium, is mined at Lac Allard, Quebec. The raw ore is shipped to Tracy, Quebec, where it is beneficiated, and the concentrate smelted to produce high quality pig iron and titania (TiO_2) slag (Sorelslag), which is used as feedstocks by titanium dioxide pigment producers.

The slag produced from ilmenite mined at QIT's mine is suitable as feedstock for titanium dioxide pigment produced by the sulphate process plants, which are gradually being phased out and replaced by chloride process plants that require higher quality slag. Because of its major shareholding in Richards Bay Minerals (RBM) of South Africa, QIT is able to maintain its market share by supplying RBM's 85 per cent TiO_2 slag to chloride process pigment plants.

In April 1986, QIT entered into a joint venture partnership with the Madagascar government to develop beach sand deposits containing good quality ilmenite. If results of exploration and feasibility studies warrant it, preliminary plans call for QIT to develop and begin mining the deposits by the end of 1989. The tentative mining rate would be 300 000 tpy of ilmenite, which would be smelted at Tracy, Quebec to produce 200 000 tpy of 90 per cent TiO_2 slag. This slag would be suitable for both types of pigment plants.

Most of QIT's output of Sorelslag is exported to the United States and Europe, and approximately 10 to 15 per cent is sold in Canada to two pigment producers, NL Chem Canada, Inc. at Varennes and Tioxide Canada Inc. at Tracy, Quebec. Both pigment producers employ the sulphate process.

The total Canadian consumption of titania pigment, about 80 000 tpy, approximately matches the present total Canadian production capacity. However, some grades of pigment are imported, the total amounting to about 24 000 t in 1985. The balance of Canadian production is exported, mainly to the United States.

The new chloride process pigment plant announced by NL Chem Canada Inc. in 1985 is scheduled to begin production in the third

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quarter of 1987 and reach its full production capacity of 38 000 tpy in late-1988. The principal feedstock for the plant will probably be RBM 85 per cent TiO_2 slag supplied by QIT, supplemented by natural or synthetic rutile. Later feedstock supplies could include 90 per cent TiO_2 slag smelted from Madagascar ilmenite.

Chloride processes for producing pigment have been gradually replacing sulphate plants, mainly for environmental reasons. They produce less waste products because they recycle the chlorine reagent and generally use higher grade feedstocks such as rutile, synthetic rutile and high quality slag. On a cost per unit of TiO_2 basis titaniferous slag is said to be slightly cheaper than natural and synthetic rutile.

Both Canadian pigment companies have been able to increase production to a marginal extent with their existing sulphate process plants. However, neither company has plans for the construction of new plant capacity beyond NL's current chloride plant project.

A small number of Canadian companies make finished products from titanium forgings, castings, bar, pipe, tube, plate and sheet. Walbar of Canada Inc. of Toronto, Ontario and Pratt & Whitney Aircraft Services of Canada Limited of Longueuil, Quebec, carry out machining operations on forgings, investment castings, and bar stock to produce parts for turbine engines. The shop scrap is sold to U.S. producers of ferrotitanium and briquettes, which are made from titanium scrap and offgrade sponge. The total amount of titanium forgings, castings and bar stock consumed by these two companies in 1985 was in the order of 300 t.

Titanium Ltd. of St. Laurent, Quebec and Ellett Copper & Brass Co. Limited of Port Coquitlam, British Columbia, custom produce titanium tanks, pressure vessels, heat exchangers, fans, and other equipment for pulp, chemical, petrochemical and metallurgical industries.

The aircraft companies, The de Havilland Aircraft of Canada, Limited, Downsview, Ontario, Canadair Limited, Montreal, Quebec, and McDonnell Douglas Canada Ltd., Malton, Ontario, produce aircraft parts such as firewalls, motor mounts, nacelles and wings. The quantities of titanium used in making chemical equipment and airframes in Canada vary widely, but appear to be in the order of 50 to 150 tpy for chemical equipment and 10 to 50 tpy for aircraft parts.

The quantities of titanium added as ferrotitanium and composite master alloys to specific grades of steels are small compared with some alloying elements. They nevertheless accounted for approximately 270 t of contained titanium in 1985 and an estimated 340 t in 1986. Used as an alloying agent, titanium is beneficial in controlling nitrogen and acts as a grain refiner in high-strength, low-alloy steel plate; it is also used as a carbide stabilizer in type 409 stainless steel. By comparison, the quantities of titanium added to aluminum alloys are of a much smaller order, possibly about 10 tpy of titanium in 5 to 10 per cent titanium-aluminum master alloys.

The quantities of titanium used by Canadian companies producing wear resistant parts for the mining and other industries are very small and are not separately reported in statistics. Titanium is used in mixed carbides with tungsten, and in titanium nitride coatings. Canadian companies producing carbides and nitrides include Kennametal Ltd., Canadian General Electric Company Limited and Valenite-Modco Limited.

WORLD

Titanium Minerals

Ilmenite, an iron titanate, is the source for 90 per cent of the world supply of titanium dioxide pigment production. The more expensive rutile, a titanium dioxide mineral, is sometimes used by the chloride segment of the pigment industry and is generally favoured by producers of primary titanium metal. Anatase, another titanium dioxide mineral, exists in large quantities in Brazil and is likely to become another important feedstock.

Titaniferous slag and synthetic rutile, which are produced by different processes from ilmenite, are high-grade feedstocks which are growing in prominence as world reserves of natural rutile are depleting. The availability of these alternative materials should tend to reduce the upward pressure on natural rutile prices given generally stable market conditions.

Titanium Dioxide Pigment

According to earlier projections by E.I. du Pont de Nemours and Company, the largest producer of TiO_2 pigment in the world, worldwide demand is growing at the rate of 1.5 per cent per year, while the Asian, Pacific and Latin American regions are growing at double this rate. The approximate consumption by use is 60 per cent in paint, 13 per cent in paper, and 15 per cent in plastics, with the remainder spread more or less evenly between, rubber, ink, textiles and ceramics. North America's usage in paper (20 per cent) exceeds the average for the rest of the world by a substantial margin.

As a result of mergers and acquisitions over recent years, there are now four major world pigment producers: du Pont, Tioxide International Ltd., NL Chemicals, and SCM Corporation. Concern over the large amounts of dilute sulphuric acid and ferrous sulphate waste generated by the sulphate process plants has prompted companies either to install expensive waste treatment facilities or, because of the consequent increase in operating costs, to terminate operations as has happened in the United States. Part of the lost capacity has been replaced by chloride process plants, built mainly outside of North America.

Since the closures occurred largely during the last period of weak demand, plans for replacement capacity have lagged behind the strong resurgence of demand since 1984. Furthermore, profit margins in the industry had been relatively low. The major titanium dioxide pigment producers are integrated chemical producers and must choose between alternative areas to invest their available capital.

Operating costs in the chloride process are approximately in the proportions 40 per cent fixed costs, 40 per cent variable costs, 10 per cent laboratory and 10 per cent plant materials. The largest variable cost is in raw materials, but the biggest unit operating cost is in "finishing", which involves re-slurrying and re-drying in order to coat the pigment particles with compounds which reduce the absorption of ultraviolet light. The latter causes the deterioration of organic paint bases.

Apart from raw materials, a large component of sulphate process operating cost is sulphuric acid. Fossil fuel energy is the next largest cost component. Fuel and acid costs were fairly stable in 1986.

Titanium Metal

Titanium metal comprises less than 6 per cent of total titanium ore demand. World consumption of titanium sponge increased in the late-1970s and reached an all-time peak of 51 412 tpy in 1981. This rapid growth stimulated increases in production capacity, which in 1983 totalled about 68 000 tpy of primary titanium in the market economies. Global capacity included about 33 400 tpy in the United States, 38 900 tpy in Japan where the greatest expansions took place, and 5 000 tpy in the United Kingdom. However, the U.S.S.R. had the world's largest production capacity, reported to be approximately 50 000 tpy. China's capacity has been estimated at about 2 500 tpy.

The western world capacity for ingot melting amounted to a total of about 80 000 tpy in 1984, including 59 000 tpy in the United States, 13 000 tpy in Japan, 5 000 tpy in the United Kingdom, 2 000 tpy in West Germany and 1 000 tpy in France.

U.S. consumption of titanium sponge declined in 1985 to 19 600 t from 22 400 t the previous year. In 1986, the total for the first three quarters was only 13 500 t, indicating a further decline for the year to a probable 17 500 to 18 500 t. U.S. production of sponge through September 1986 was 11 700 t, a considerable reduction from 1985. Production in Japan dropped 20 per cent in 1986, with an accompanying decline in exports and a rise in inventories.

Titanium ingot consumption in the United States declined from 35 400 t in 1984 to 33 700 in 1985, and was 23 500 t for the period January through September 1986. Probable overall U.S. ingot consumption in 1986 was 31 000 to 32 000 t. U.S. ingot production over the whole of 1986 was probably close to the 1985 total of 32 500 t.

The consumption of mill products in the United States amounted to 21 000 t in 1985 while 14 400 t was consumed in the first three quarters of 1986. The total for 1986 was probably about 18 500 t.

A rather flat market for titanium metal products existed throughout 1986 despite strong orders for commercial aircraft. Various explanations have been suggested by industry experts; it has been pointed out that the newer aircraft being ordered use less titanium and that the quantity of titanium purchased to produce a given finished part is gradually being lowered by technology improvements. Titanium demand was also adversely affected by postponements in industrial uses, notably nuclear and desalination plants.

The distribution of usage for mill products in 1984 was estimated by the United States Bureau of Mines to be 75 per cent for aerospace and 25 per cent for industrial applications in the United States. Japan's consumption depends far less on the volatile military market; less than 10 per cent is used in aerospace applications and more than 90 per cent in industrial applications. In western Europe, industrial applications account for 40 to 50 per cent of consumption with the remaining consumption in aerospace.

WORLD DEVELOPMENTS

Australia: By mid-1987, the production of synthetic rutile is expected to be available from the new plants under construction by Westralian Sands Ltd. and Western Titanium Ltd. When at full capacity, the combined output from these two companies will jump from 60 000 to 272 000 tpy of synthetic rutile, with the concurrent loss to the market of about 360 000 tpy of ilmenite.

The TiO_2 Corporation NL has proceeded with its plans, announced in 1985, for the development of dune deposits at Jurien and Cooljarloo in Western Australia and expects to begin production towards the end of 1987. Estimated production volumes were reported to be 93 000 and 113 000 t ilmenite, respectively, and 26 300 t and 21 700 rutile/leucoxene, respectively.

Sierra Leone: Nord Resources Corp. plans to increase its Sierra Rutile mining capacity from its present 100 000 tpy to 125 000 tpy by early-1987 by opening up two more deposits. Sierra Rutile may also begin production of about 30 000 tpy of a high-grade, low-chrome ilmenite in 1987, if ilmenite prices rise sufficiently.

Brazil: Construction began in March 1986 on the previously announced plant for producing 90 per cent TiO_2 anatase concentrate at the Tapira mine in Minas Gerais. However, the owner, Companhia Vale do Rio Doce (CVRD), decided to increase the capacity of the plant from the originally conceived 300 000 tpy to 400 000 tpy. Production is due to begin in 1987. In addition, E.I. du Pont de Nemours and Company (DuPont) is expected to bring its new 60 000 tpy pigment plant into operation at Araxa in 1988.

South Africa: Richards Bay Minerals (RBM) was scheduled to raise its production capacity to 650 000 tpy from 440 000 tpy of 85 per cent TiO_2 slag by the end of 1986. The expansion has included the addition of a new bucket wheel dredge and a third smelting furnace. An additional output of 26 000 tpy of natural rutile might be expected as a result of the mining expansion.

Norway: The new plant of K/S Ilmenittsmelteverket A/S at Tyssedal, Norway, designed to produce 200 000 tpy of 75 per cent TiO_2 slag, is scheduled to be in full operation in January 1987.

China: SCM Corporation of the United Kingdom was reported to be entering a joint venture to produce 120 000 tpy of synthetic rutile in China from by-product ilmenite from iron mining near Dukou, subject to favourable results from a feasibility study that was in progress. The product would be used as feedstock for a proposed pigment plant in China. The latter would have about 40 000 tpy of capacity and would be based on SCM's chloride technology.

Saudi Arabia: Kerr-McGee Chemical Corporation of the United States and Shairco Ltd. of Saudi Arabia will each own 25 per cent of a new company called Crystal Pigment Company, which is scheduled to construct a 45 000 tpy pigment plant at Yanbu, Saudi Arabia, by mid-1989. The plant will use the Kerr McGee chloride process technology. All feedstock is to be imported and most of the product exported.

Taiwan: Previously announced plans for a DuPont pigment plant of 60 000 tpy capacity, which was initially scheduled for construction in 1987, were suspended because of local concerns for safety.

Korea: Lucky Advanced Materials, Inc. began construction of a facility at Samilmyon to produce about 30 000 tpy of titanium tetrachloride from imported rutile. The plant will use production technology provided by Kerr-McGee Chemical Corporation of the United States.

India: A plant designed to produce 100 000 tpy of synthetic rutile was commissioned at Orissa in mid-1986. It was expected to approach full production by the end of 1986.

United States: A rock, sand and gravel operation, owned by P.W. Gillibrand Co. and located in the Solidad Canyon area in California, may yield a heavy mineral concentrate by-product through the addition of more beneficiation equipment. The likely scale of production would be 50 000 to 100 000 tpy of concentrate containing about 33 per cent ilmenite, 20 per cent magnetite, 27 per cent apatite and 4.5 per cent zircon. The company did not indicate a date for the proposed installation.

An agreement between the Timet Division of Titanium Metals Corp. of America and Nippon Steel Corporation of Japan provides for Timet to supply Nippon with titanium rolling technology for new facilities to be completed in 1987. In addition, Timet will sell Nippon titanium alloy ingot and Nippon will become Timet's exclusive sales' agent in Japan for aerospace-grade titanium mill products.

A previously announced joint venture, ALS Metals Co., between Allegheny Ludlum Steel Corp. and Sumitomo Metal Industries, Ltd. was in the process of dissolution. ALS imported Sumitomo's semifabricated titanium mill products into the United States for further milling to flat products and welded tubing. The increased value of the Japanese yen versus the dollar is said to have been the main factor in the failure.

Superplastic forming (SPF) and diffusion bonding (DB) capacity has been doubled by McDonnell Aircraft Co., a division of McDonnell Douglas Corporation. A new 1 000 t press has been installed, costing $2.5 million. Superplastic forming of titanium sheets is carried out in an inert atmosphere at high temperature. Deformations up to several hundred per cent are attainable in producing complex shapes.

Japan: A new process for cladding titanium onto steel plate was announced by Nippon Kokan KK of Japan, using a novel hot rolling technology as opposed to the more well known explosion cladding technology. The company expects to offer cladded plate at substantial cost savings for industrial and marine applications that require high corrosion resistance.

PRICES

As a result of the general over-capacity of sponge, melting and milling production, coupled with the somewhat static demand, metal prices generally remained depressed. Sponge prices were $US 3.50 to $4.00 per lb. at 1985 year-end and firmed up somewhat to $3.90 to $4.30 per lb. near the end of 1986. The price of titanium 6Al4V alloy 8 1/8 inch round billet fell to a low of $7.10 to $7.76 per lb. compared with a list price of $8.01, while estimated market prices for 2¼ inch round bar were $9.25 to $10.04 per lb. compared with a list price of $10.06.

USES

Titanium metal usage is based on its relative abundance, unique physical properties and corrosion resistance. Initially, uses were found in military aircraft where cost was not the main factor, and its high-strength, lightness and high melting point could be utilized for engine and airframe applications. Greater availability and lower prices have led to expanding usage in commercial and private aircraft. Specifications for aircraft quality are high, and since titanium has a strong tendency to combine with oxygen and nitrogen, melting has to be carried out in vacuum, sometimes twice or three times before an ingot is produced for fabrication.

Commercial titanium that is unalloyed or produced to less demanding specifications is used in industrial applications. Titanium's high corrosion resistance lends itself to a wide range of uses in the chemical, metallurgical and paper industries, and in power and desalination plants. In these applications, about 50 per cent of the total quantity of titanium consumed is used in heat transfer and seawater cooling applications, about 25 per cent in chemical process equipment, and about 20 per cent as electrodes in electrolytic plants. However, a vast number of minor applications are developing, such as spectacle frames, camera parts, yacht rigging, and prosthetic uses such as hip joints and dental implants. Titanium-nickel shape memory alloys, which spring back to their original shape when heated, are gaining a wide range of uses in high pressure pipe couplings, electronic connectors, robotics and eyeglass frames.

TECHNOLOGICAL DEVELOPMENTS

Mill producers have been caught in a squeeze between low prices and high operating costs, which could result in the closure of some operations. This situation particularly affects non-integrated producers whenever sponge and scrap prices are firmer than those of mill products. Although lower prices would be necessary for titanium to penetrate markets now served by aluminum and stainless steel, further production cost reductions would be necessary to enable this to happen to any substantial extent. A fundamental improvement would result from lower production costs for titanium sponge. Towards this end, Albany Titanium, Inc. of the United States and Elettrochimica Marco Ginatta of Italy have carried out pilot studies on a fluosilicate leach and a fused salt electrolysis approach, respectively, for primary titanium. Both companies have also announced plans for commercial development, which so far have not reached the construction stage.

While no commercial breakthrough has yet occurred in primary titanium production, progress continues to be made on post-primary metal treatments including melting, forming, casting, recycling and powder metallurgical technologies, which have had the overall effect of reducing the cost of the finished parts, and improvements in quality. Much of the development work has been aimed at reducing excessive machining operations between the ingot and fabricated part stages. The cost and material savings obtained from the development of net-shape and near-net-shape techniques have enabled designers to specify titanium alloys in an expanded range of applications. The greatest commercial success in this regard has so far occurred through developments in precision casting techniques, which have enabled parts to be made in one piece instead of an assembly of many. Although not as successful so far, powder metallurgy techniques enable a very high utilization of material, albeit with unit size limitations. Also, super plastic forming and diffusion bonding are gaining use because this technology enables the design of large complex structural shapes with fewer component parts. Electron beam and plasma melting in inert atmospheres are being developed to larger scale and are replacing vacuum arc melting to some extent.

In the field of alloy development, the workhorse 6/4 alloy is being replaced for some applications by other alloys. For example, where better cold formability is required the alloy Ti3Al2.5V is being used. Although not as strong as 6/4, the 3/2.5 has excellent ductility, which enables its use in complex and severely bent tubing shapes. For industrial uses requiring corrosion and abrasion resistance, unalloyed titanium is normally used, either in solid form or as cladding on a steel base. Explosion cladding has been the state-of-the-art technology but Nippon Kokan KK recently announced that it has developed technology for cladding by hot rolling, which has hitherto been impossible because of the formation of brittle intermetallic compounds at elevated temperatures. Surface modification based on electron beam or plasma techniques is also being carried out by various firms to provide corrosion and abrasion resistance. New titanium matrix composites and titanium aluminides are foreseen as having the potential to push titanium into higher strength-to-density ratios and higher temperature usage. Alloying progress is also being made in the areas of superconductive TiCb alloys and shape-memory TiNi alloys. Indirectly, some savings in sponge production costs have been achieved through more successful upgrading of titanium scrap for recycling to sponge production.

In its first three years of operation, the Titanium Development Association has been active in compiling information for its growing membership, and in promoting the development of markets and technology through publications, trade shows and conferences. It hosted a very successful conference on titanium products and applications at San Francisco during October 1986.

OUTLOOK

The depletion of natural rutile supply will continue to encourage the conversion of ilmenite to titaniferous slag and synthetic rutile to meet the rising demand. The eventual impact of anatase concentrates on this market will depend on supplies, prices and the relative suitability of all the alternative feedstocks to the two basic pigment processes. Production plans for feedstocks of all kinds appear to be adequately in balance with the anticipated growth in demand into the early-1990s, and any future price increases are likely to be moderate or approximately in proportion to pigment prices.

As was the case for titanium raw materials in 1984 and 1985, the demand for titanium dioxide pigment was strong throughout the year, with plants operating near full production capacity. This market strength is expected to continue throughout 1987 in parallel with general economic trends. Increases in prices resulting from the strong demand and short supply have encouraged plans for capital investment in various countries, as outlined in the foregoing sections.

Pigment production plans have tended to lag behind demand in past years because prices have hitherto not been high enough to encourage new capital intensive greenfield plants. Stricter environmental regulations have also been a constraint. Pigment plants have been working at capacity for nearly three years in an attempt to keep customers supplied. Construction decisions have undoubtedly been made easier by increases in pigment prices, which occurred over the past year. The plans announced by pigment producers over the last two years will not result in additional capacity until 1987 through 1989, so supply is expected to remain tight into the early-1990s. On the other hand, the higher prices may reduce demand through substitution or other economies by pigment consumers.

Officials in the titanium industry foresee a fairly flat demand for metal products over the next five years. A United States interdepartmental study forecasted an overall 4.9 per cent consumption growth rate for aerospace and 6.1 per cent for other applications from a 1982 base, leading to a total fabricated titanium metal consumption of 28 000 t in 1993.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
CANADA					
32900-1	Titanium ore	free	free	free	free
34715-1	Sponge and sponge briquettes, ingots, blooms, slabs, billets, and castings in the rough, of titanium or titanium alloys for use in Canadian manufactures (expires June 30, 1987)	free	free	25	free
34735-1	Tubing of titanium or titanium alloys having an outer diameter of less than 12.7 mm or more than 63.5 mm and having a wall thickness of less than 0.457 mm or more than 1.166 mm, for use in Canadian manufactures (expires June 30, 1987)	free	free	25	free
34736-1	Sheet or strip of titanium or titanium alloys, cold-rolled, not more than 4.75 mm in thickness, for use in the manufacture of tubes (expires June 30, 1987)	free	free	25	free
34745-1	Bars, rods, plate, sheet, strip, foil, wire, coated or not; forgings and mesh of titanium or titanium alloys, for use in Canadian manufactures (expires June 30, 1987)	free	free	25	free
37506-1	Ferrotitanium	free	4.2	5	free
92825-1	Titanium oxides	free	10.3	25	free
93207-6	Titanium whites, not including pure titanium dioxide	free	10.3	25	free

MFN Reductions under GATT (effective January 1 of year given)	1986	1987
37506-1	4.2	4.0
92825-1	10.3	10.0
93207-6	10.3	10.0

UNITED STATES (MFN)			
422.30	Titanium compounds	5.2	4.9
473.70	Titanium dioxide	6.2	6.0
601.51	Titanium ore (including ilmenite, ilmenite sand, rutile, and rutile sand)	Remains free	
606.46	Ferrotitanium and ferro-silicon titanium	3.9	3.7
629.12	Titanium metal, waste and scrap	8.6	7.2
629.14	Titanium metal, unwrought	15.5	15.0
629.20	Titanium metal, wrought	15.5	15.0

Sources: The Customs Tariff, 1986, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated (1986), USITC Publication 1775; U.S. Federal Register Vol. 44, No. 241.

TABLE 1. CANADA, TITANIUM PRODUCTION AND TRADE, 1984-86

	1984		1985		1986P	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Production (shipments)						
Titanium dioxide, slag	x	x	x	x	x	x
Imports					(Jan.-Oct.)	
Titanium in ores and concentrates						
United States	1 596	1,005	1 619	1,147	2 466	874
Australia	2 092	869	340	150	119	59
South Africa	36	2	-	-	-	-
Total	3 724	1,876	1 959	1,297	2 585	983
					(Jan.-Sept.)	
Titanium dioxide, anatase						
United States	7 980	14,399	2 657	4,705	757	1,559
West Germany	2 660	3,676	5 650	7,488	4 525	7,047
Australia	691	1,392	800	1,458	0	0
France	909	1,273	903	1,389	222	394
Belgium-Luxembourg	492	685	331	471	366	608
United Kingdom	714	974	209	325	56	104
Spain	990	2,007	464	657	0	0
Other countries	1 752	2,516	1 683	2,208	175	285
Total	16 188	26,922	12 696	18,703	6 101	9,998
Titanium dioxide, rutile						
West Germany	4 987	6,164	2 116	2,761	3 654	6,681
United States	1 461	3,063	6 862	11,622	7 231	13,002
Belgium-Luxembourg	94	140	350	506	54	112
Spain	304	477	429	675	217	338
Other countries	2 522	3,633	2 670	4,352	3 054	5,705
Total	9 369	13,477	12 427	19,916	14 210	25,838
Titanium metal						
United States	267	7,342	479	15,110	272	9,628
Belgium-Luxembourg	5	480	8	831	8	861
United Kingdom	17	393	25	573	39	710
Japan	52	487	72	734	33	361
Other countries	14	1,330	3	206	2	60
Total	355	10,032	587	17,454	354	11,620
Ferrotitanium[1]						
United Kingdom	28	115	100	373	159	643
Belgium-Luxembourg	28	127	-	-	-	-
Italy	-	-	-	-	18	84
United States	232	837	288	1,153	189	747
Total	286	1,078	388	1,527	366	1,476
Exports[2] to the United States						
Titanium metal, unwrought, including waste and scrap	178	384	146	350^e	199	477
Titanium metal, wrought	192	3,561	390	7,000^e	295	5,241
Titanium dioxide	23 779	29,391	24 184	30,000^e	16 776	21,551
Titanium slag			177 100	-	124 820	25,004

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Total alloy weight. [2] U.S. Department of Commerce, U.S. General Imports, Report F.T. 135. Canadian export statistics do not provide separate categories.
P Preliminary; ^{e} Estimate; - Nil; x Confidential.

TABLE 2. CANADIAN TITANIUM PRODUCTION AND IMPORTS 1970, 1975 AND 1979-86

	Production		Imports		
	Ilmenite[1]	Titanium Dioxide Slag[2]	Titanium Dioxide Anatase	Titanium Dioxide Rutile[3]	Total Titanium Dioxide Pigments
			(tonnes)		
1970	1 892 290	766 300	2 523	7 415	9 938
1975	1 543 480	749 840	2 467	241	2 708
1979	1 004 260	477 030	9 815	1 515	11 330
1980	1 853 270	574 710	6 135	148	6 283
1981	2 008 117	759 191	6 986	314	7 300
1982	1 735 000	669 000	5 737	369	6 106
1983	x	x	12 968	5 555	18 523
1984	x	x	16 188	9 369	25 557
1985	x	x	12 696	12 427	25 123
1986[3]			6 101	14 210	20 311

Sources: Energy, Mines and Resources Canada; Statistics Canada; Company reports.
[1] Ore treated at Sorel; from company reports. [2] Slag with 70 to 72 per cent TiO_2; from company reports. [3] Jan.-Sept. 1986.
x Withheld.

TABLE 3. PRODUCTION OF ILMENITE CONCENTRATE BY COUNTRIES, 1982-85

	1982	1983	1984P	1985^e
		(000 tonnes)		
Australia	1 169	906	1 098	1 216
Canada[1]	669	635^e	720	744
Norway	552	544	550	635
$U.S.S.R.^e$	431	435	440	440
Republic of South Africa	381	417	417	417
United States	239	W	W	W
$India^e$	153	150	150	154
Finland	168	163	167	127
China	136	140	140	141
Malaysia	101	223	195	181
Sri Lanka	68	82	80	82
Brazil	-	48	50	50
Other countries	15	-	-	-
Total	4 082	3 743	4 007	4 187

Sources: U.S. Bureau of Mines, Minerals Yearbook Preprint, 1983; U.S. Bureau of Mines, Mineral Commodity Summaries, 1985.
[1] Titanium slag containing 70-71 per cent TiO_2 to end of 1983; 80 per cent TiO_2 after 1983.
P Preliminary; ^{e} Estimated; - Nil;
W Withheld to avoid disclosing company proprietary data.

TABLE 4. PRODUCTION OF RUTILE BY COUNTRIES, 1982-1985

	1982	1983	1984P	1985^e
		(000 tonnes)		
Australia	221	163	182	182
Sierra Leone	48	72	91	91
Republic of South Africa	47	56	56	56
United States	W	W	W	W
Sri Lanka	7	9	8	9
Central	10	10	10	10
$India^e$	7	7	7	8
Brazil	--	1	1	-
Total	340	318	355	355

Sources: U.S. Bureau of Mines, Minerals Yearbook Preprint, 1982; U.S. Bureau of Mines, Mineral Commodity Summaries, 1985.
P Preliminary; ^{e} Estimated; -- Amount too small to be expressed; W Withheld to avoid disclosing company proprietary data.

TABLE 5. LISTED PRICES OF SELECTED TITANIUM COMMODITIES, 1984-86

	1984	1985	1986
Titanium ore, f.o.b. cars Atlantic and Great Lake ports			
Rutile, 96 per cent, per short ton, delivered within 12 months	$A 400.00-420.00	$A 510.00-530.00	$A 560-870
Ilmenite, 54 per cent, per long ton, shiploads	$A 40.00-43.00	s	s
Titanium sponge, per lb.	5.55-5.85	5.55-5.85	s
Mill products, per lb. delivered			
Billet (Ti - 6AL-4V)	$US 8.35	$US 8.35	$US 8.01
Bar (Ti - 6AL-4V)	$US 9.77	$US 9.77	$US 10.06
Titanium dioxide, anatase[1],			
Bags, 20-ton lots, freight allowed, per lb.	0.69-0.70	0.69-0.70	0.77-0.79
Titanium dioxide, rutile, regular grades, per lb.	0.75	0.75	0.81-0.84

Source: Metals Week, December.

[1] Chemical Marketing Report, December.

f.o.b. - Free on board; s List price suspended.

Tungsten

D.R. PHILLIPS

SUMMARY

The primary tungsten industry encountered extreme hardship in 1986 because of rapidly falling prices, which resulted in the closure of most of the western world producers of tungsten concentrate.

Canada Tungsten Mining Corporation Limited (Cantung), a subsidiary of AMAX Inc. and Canada's last producer of tungsten, ceased production in May 1986 at its mine in Tungsten, Northwest Territories.

Prices in May, which stood at an average of $US 51.50 for wolframite and $US 56.57 for scheelite per tonne unit, declined to a new low in the latter half of 1986 to $US 30-43 per tonne (t) unit.

CANADIAN DEVELOPMENTS

Canada ranked third among world producers of tungsten in 1985, with estimated production of 3 005 t of tungsten in ores and concentrates, but only produced an estimated 1 200 t in 1986 due to the closure of all mines.

Mount Pleasant Tungsten mine in New Brunswick, which closed in June 1985, terminated production primarily because of falling prices. Canada Tungsten Mining Corporation Limited (Cantung), which was idled by a strike at its mine in May 1986, announced in August 1986 that the mine would remain closed for an indefinite period due to weak markets and low prices for tungsten concentrate.

Canada is well positioned with respect to tungsten resources and potential production capability. The Cantung mine could be returned to production on short notice and the Mactung property would take only slightly longer to bring on-stream. Under favourable market conditions, Canadian production could account for about 25 per cent of the world export market, as compared to about 20 per cent of the market in recent years.

In 1986, Cantung acquired all tungsten interests that were held by its parent AMAX Inc. The main assets now held by Cantung include its mine at Tungsten, Northwest Territories, the Mactung deposit about 200 km to the north, which has been reported to be the largest and highest ore grade deposit in the world, and an ammonia paratungstate plant at Madison, Wisconsin, which has been leased to Cantung on a long term basis.

INTERNATIONAL DEVELOPMENTS

The decrease in the world production of tungsten ores and concentrates in 1986, which was estimated at 38 600 t of contained tungsten, represented a reduction of 11 per cent compared to 1985. The ranking of world tungsten producers in order of their 1986 estimated production was: The People's Republic of China (12 500 t), the U.S.S.R. (9 100 t), South Korea (2 200 t), Australia (1 650 t) and Austria (1 500 t).

Most western world producers of tungsten concentrate closed in 1986 or indicated they would close by year-end due to continued low prices. Several press reports on trade cited the marketing of intermediate tungsten products by China, at prices which apparently did not reflect the cost of upgrading the concentrate from which these products are made, as a major cause of continued low prices.

Excess mine capacity, which was built in the late-1970s to take advantage of high prices, has been a chronic problem. The tungsten industry in the western world operated at about 55 per cent of capacity in recent years, and less than 50 per cent in 1986. Although world consumption of tungsten was strong during this period, it was not sufficient to absorb production from all the newly installed capacity.

Based upon calculations made from published statistics, world consumption has exceeded production during the past 4 years by 4 000 tpy of tungsten on average. This

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implies that mine production has been supplemented by commercial stocks during this period, a situation which is not expected to continue much longer. However, world production statistics may not be reliable as they cannot be verified, which puts in question whether stocks are really being depleted.

The passage of the United States bills calling for the suspension of the tariff on tungsten contained in ores and concentrates has been delayed. The substance of the bills, introduced in the United States Senate by Senator Grassley (R-Iowa, S-1014) and in the House of Representatives by Congressman Flippo (D-Al HR2360) for the suspension of the 17 cents per pound tariff was included in an omnibus trade bill and referred to the Ways and Means Committee in 1985. The omnibus trade bill was passed by the House in May 1986. However, its counterpart was defeated in the Senate later in the year. The tungsten item was subsequently included in a miscellaneous tariff bill, which was passed by the House in 1986 but has not yet been dealt with by the Senate.

In the United States, the Strawberry mine, of Teledyne Tungsten near North Fork, California (TWCA), was the only North American tungsten mine operating at the close of 1986. This mine might also have to close due to low prices.

The People's Republic of China (PRC) was the world's largest producer of tungsten ore in 1986, followed closely by the U.S.S.R. Tungsten production in the PRC was reported to be 12 500 t, about the same level as in 1985. Tungsten production in the U.S.S.R. in 1986 was estimated to be 9 100 t.

Australian production of tungsten in 1986 was estimated at 1 625 t tungsten content, about 15 per cent less than 1985. All Australian tungsten mines, except the King Island Scheelite mine of Peko-Wallsend Ltd., were closed by year-end 1986. King Island Scheelite operated at about 50 per cent of capacity during the year.

South Korea, which operated at about 80 per cent of capacity in 1986 was the third largest producer of tungsten ores and concentrates in 1986. Production was estimated at 2 200 t.

Austria produced an estimated 1 500 t of tungsten contained in ores and concentrate in 1986, a decrease of 11 per cent compared to 1985. This production level represented about 94 per cent of Austrian production capacity.

Tungsten producers in both Thailand and Bolivia operated at about 30 per cent of capacity in 1986. Bolivia's 1986 production of ores and concentrates, at about 1 300 t of contained tungsten, remained at the same level as 1985. Thailand's production of 585 t of tungsten contained in ores and concentrates decreased 21 per cent in 1986 compared to 1985.

MARKET STABILIZATION

International discussions on stabilizing the tungsten market were held at the 18th Session of the United Nations Committee on Tungsten (COT) in Geneva on November 3-7, 1986. This session included the second meeting of the Sessional Working Group (SWG).

The SWG recommended to the COT that the Secretariat undertake, inter alia, studies on:

(i) Characterization of the current crisis of the market and of the primary tungsten and intermediate products industry;

(ii) In-depth analysis of the origins of the crisis;

(iii) Changing patterns of production, trade and marketing of intermediate products;

(iv) Structural and technological change, particularly in the area of substitution and reduced usage of tungsten, including related research and development and market promotion;

(v) The relationship of exchange rate variations and local currency prices to supply and demand trends.

PRICES

After a short-term recovery and reaching a temporary high in October 1985, prices reversed and fell abruptly during 1986. The quoted price for scheelite concentrate declined from $US 68/t unit in October 1985 to $US 43 in November 1986. Wolframite concentrate declined in price from $US 72 to $US 30.

The International Tungsten Indicator decreased from $US 64 in October 1985 to $US 41.44 by December 1986.

Prices reported by the Metal Bulletin (MB) and by the International Tungsten Indicator (ITI) for the months February, July and November 1986 are summarized as follows.

	MB		ITI
	Wolframite	Scheelite	Tungsten Concentrate[1]
	($US/tu[2] WO_3)		
Feb.	55-63	62-70	62.78 - 66.95
July	44-56	44-58	52.16 - 57.24
Nov.	30-44	43-55	45.57 - 47.64

[1] Concentrate price based on an average WO_3 content related to monthly transactions.
[2] One tonne unit (tu) of WO_3 contains 7.93 kilograms of tungsten.

USES

Approximately 80 per cent of the western world tungsten consumption in 1986 was accounted for in the manufacture of cemented carbide and tool steel products, the former amounting to approximately 50 per cent of total consumption. Tungsten metal, superalloys and miscellaneous end-uses accounted for the remaining 20 per cent.

Major consumers of tungsten include the oil and gas, mining, manufacturing and farm equipment industries.

Tungsten materials can be divided into several major classes, depending upon the product form and its use. The main product forms include tungsten carbide, tungsten-bearing steels, superalloys, mill products made essentially from pure metal, and chemicals.

Tungsten carbide (WC) is one of the hardest materials known and accordingly, has widespread applications where intense wear and abrasion are encountered. This product is the preferred metalworking material for the cutting edges of machine tools and as a metal surface in forming and shaping dies. It is produced by the chemical combination of tungsten metal powder and finely divided carbon. Tungsten carbide is compacted to the desired form, using cobalt as a binder, and sintered to produce cemented tungsten carbide. Cutting tools of cemented tungsten carbide are used for machining steel, cast iron and nonferrous metals, and for shaping in the woodworking and plastics industries. Cemented tungsten carbide is also used to make dies for wire and tube drawing, punches and dies for metal forming, and bits and tools for drilling equipment and wear-resistant parts. With the addition of tantalum, titanium and columbium carbides, the coefficient of friction of cemented tungsten carbides is lowered, thereby producing grades better suited to the machining of specific items, particularly steel products. Other uses of tungsten carbide are in tire studs, spikes for golf shoes, armour-piercing projectiles and welding electrodes.

As an alloy constituent, tungsten is used primarily in the production of high-speed steels, and tool and die steels. Tungsten is added to steels either as ferrotungsten (80 per cent tungsten), melting base (30-35 per cent tungsten), scheelite ($CaWO_4$) or as tungsten-bearing scrap. Tungsten-bearing steels are used for the same applications as carbides, especially where lower operating temperatures are encountered. Tungsten is also used in some stainless steels for applications in high-temperature environments.

Tungsten is an important constitutent in a wide variety of superalloys and nonferrous alloys. Tungsten-containing superalloys are being used increasingly in high-temperature applications and in highly corrosive environments because of their high-temperature strength and oxidation resistance. In making the alloys, tungsten is usually added in the form of metal powder, although scrap can be used to satisfy part of the requirements. Superalloys can be classified into three principal types: nickel base, iron base and cobalt base or stellite superalloys. While only small amounts of tungsten are currently used in the nickel and iron base superalloys, several companies are developing new superalloys containing larger amounts of tungsten, a factor which could significantly expand the market for tungsten.

Mill products made from pure or nearly pure tungsten metal powder are used in significant quantities by the electrical industries. The relevant important properties of tungsten for electrical applications include its high-melting point, low-vapour pressure, hardness, good electrical conductivity and low coefficient of thermal expansion. Tungsten mill products such as rods, wire and flat products are made by compressing tungsten metal powder into the desired shape and then sintering.

Discs cut from tungsten rods are used as electrical contacts to improve resistance to heat deformation resulting from sparking and associated high temperatures. Tungsten discs are also used as heat sinks in semiconductor applications and, in combination with other elements, as electrical contacts and breakers for industrial use.

Tungsten wire is used for filaments in incandescent lamps, and heating elements in both fluorescent lamps and vacuum tubes. The overall demand for tungsten wire is increasing in response to the upward trend in the manufacture of lamps and new uses such as de-icing and defogging elements in automobile glass.

Flat products are used for various parts of electron tubes and radiation shields as well as for very high-temperature applications in reducing or inert atmospheres.

Tungsten is used for counterweights and balances, especially by the aircraft industry, and it is replacing depleted uranium which has about the same density, in similar applications.

Minor amounts of tungsten are used to make chemicals and compounds for nonmetallurgical applications. Some of the end-uses include dyes, chemical reagents, catalysts, lubricants, paints and varnishes.

OUTLOOK

Prices for tungsten are forecast to increase significantly by the end of 1987 from their catastrophic low in 1986. The increase is mainly attributed to an anticipated depletion of commercial stocks in 1987, reduced global production in 1987 to 34 500 t compared to 38 600 t in 1986 and consumption of 45 000 t, a modest increase of 2 per cent over 1986.

The production level of 34 500 t assumes that the mines which closed in 1986 will not reopen in 1987.

Low prices are expected to persist until commercial stocks are depleted and a shortage becomes imminent. At that point in time, prices may rebound strongly and remain firm until idled mines are brought back into production. Current indications are that the price recovery could begin about mid-1987 and continue well into 1988.

There is, of course, considerable danger in returning to an oversupply situation again if mine producers fail to exercise production restraint in response to evolving market conditions. Indeed, a new tungsten crisis would soon recur if producers decided to operate their mines at full capacity.

Continued low prices for tungsten could lead to the permanent closure of the mines which ceased operation in 1986. This would result in consumers in the western world becoming dependent on producers in Asia and East Europe for their supply of primary tungsten.

PRICES

	December 1985 Week Ending 27th	December 1986 Week Ending 26th
	($US)	
Tungsten ore, 65 per cent minimum WO_3		
G.S.A. domestic, duty excluded, per short ton unit of WO_3	59.160	32.000-42.769
G.S.A. export, per short ton unit of WO_3	61.250	61.250
L.M.B. ore quoted by **London Metal Bulletin**, cif Europe, per tonne unit of WO_3	54.000-62.000	31.000-45.000
MW U.S. spot ore, per short ton unit	48.000-57.000	30.000-37.000

Source: Metals Week.
cif Cost, insurance and freight.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
CANADA					
	Metals and manufactures thereof:				
32900-1	Tungsten ores and concentrates	free	free	free	free
34700-1	Tungsten metal, in lumps, powder, ingots, blocks or bars, and scrap of tungsten alloy metal, for use for alloying purposes	free	free	free	free
34710-1	Tungsten rod and tungsten wire	free	free	25.0	free
35120-1	Tungsten and alloys - not being ferro-tungsten - in powder, pellets, scrap, ingots, sheets, strips, plates, bars, rods, tubing or wire, for use in Canadian manufactures	free	free	25.0	free
	Ferro-alloys:				
37506-1	Ferrotungsten alloys used in the manufacture of steel or iron, n.o.p.	free	4.2	5.0	free
37520-1	Tungsten oxide whether in powder, in lumps or formed into briquettes by the use of a binding material; for use in the manufacture of iron and steel	free	free	5.0	free
82900-1	Tungsten carbide encased in metal tubes, for use in Canadian manufactures	free	free	free	free

MFN Reductions under GATT (effective January 1 of year given)		1986	1987
37506-1		4.2	4.0
UNITED STATES (MFN)			
	Tungsten compounds:		
422.40	Carbide	11.0	10.5
422.42	Other	10.2	10.0
	Metal bearing ores and the dross or residuum from burnt pyrites:		
601.54	Tungsten ore, per pound on tungsten content	17¢	
	Ferro-alloys:		
606.48	Ferrotungsten and ferrosilicon tungsten	6.2	5.6
	Tungsten waste and scrap:		
629.25	Containing by weight not over 50 per cent tungsten	5.2	4.9
629.26	Containing by weight over 50 per cent tungsten	4.2	4.2
	Tungsten unwrought, other than alloys:		
629.28	Lumps, grains and powders	11.3	10.5
629.29	Ingots and shot	6.8	6.0
629.30	Other	7.6	6.6
	Tungsten unwrought alloys:		
629.32	Containing by weight not over 50 per cent tungsten	5.0	4.7
629.33	Containing by weight over 50 per cent tungsten	7.6	6.6
629.35	Tungsten wrought	7.3	6.5

Sources: The Customs Tariff, 1986, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated 1986, USITC Publication 1775; U.S. Federal Register Vol. 44, No. 241.
n.o.p. Not otherwise provided for.

TABLE 1. CANADA, TUNGSTEN PRODUCTION, CONSUMPTION AND IMPORTS, 1984-86

	1984^r		1985^p		1986^e	
	(kilograms)	($000)	(kilograms)	($000)	(kilograms)	($000)
Production[1] (WO_3)	4 195 785	..	4 030 574	..	1 786 000	..
Consumption (W content)						
Tungsten metal and metal powder	642 404	..	693 829	..	661 993	..
Other tungsten products[3]	17 261	..	13 442	..	13 007	..
Total	659 665	..	707 271	..	675 000	..
Imports						
Tungsten in ores and concentrates						
United States	6 000	108	10 000	121	11 000	97
People's Republic of China	-	-	1 000	14	1 000	16
Total	6 000	108	11 000	135	12 000	113
Ferrotungsten[2]						
United States	5 000	129	1 000	39	8 000	122
Other	-	-	-	-	-	-
Total	5 000	129	1 000	39	8 000	122
Tungsten carbide powder						
United States	263 998	6,813	238 997	7,012	220 686	6,202
Other countries	30 110	741	21 227	504	40 832	1,219
Total	294 108	7,554	260 224	7,516	260 509	7,421
	(number)	($)	(number)	($)	(number)	($)
Tungsten carbide rotary rock drill bits						
United States	9 257	38,701	15 346	58,970	7 279	32,994
Other countries	1 174	5,189	1 400	6,353	998	4,870
Total	10 431	43,890	16 746	65,323	8 277	37,863
Tungsten carbide percussion rock drill bits						
Ireland	122 709	1,985	70 482	1,009	128 845	1,500
United States	51 660	1,725	62 495	2,051	115 201	2,000
Other countries	16 864	497	31 777	809	-	700
Total	191 233	4,107	164 754	3,869	278 828	4,200
Tungsten carbide tools for metal work						
United States	..	11,110	..	11,245	..	14,300
Other countries	..	3,565	..	3,311	..	6,147
Total	..	14,675	..	14,556	..	20,447

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Producers' shipments. [2] Gross weight. [3] Includes tungsten ore, tungsten carbide and tungsten wire.

p Preliminary; r Revised; e Estimated; - Nil; .. Not available.

TABLE 2. CANADA, TUNGSTEN PRODUCTION, TRADE AND CONSUMPTION, 1975 AND 1979-86

	Production[1]	Imports: Tungsten Ore[2]	Imports: Ferro-tungsten[3]	Consumption[2]
	(kilograms)			
1975	1 477 731	1 000	45 359	451 336
1979	3 254 000	11 000	28 000	380 229
1980	4 007 000	6 000	7 000	290 479
1981	2 515 000	14 000	6 000	401 447
1982	3 029 730	7 620	4 536	485 606^{r}
1983	1 537 880	12 000	3 000	503 651
1984^{r}	4 195 785	6 000	5 000	659 665
1985^{p}	4 001 870	11 000	1 300	707 271
1986^{e}	1 786 000	9 000	1 500	675 000

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Producers' shipments of scheelite (WO_3 content); [2] W content; [3] Gross weight.
^{p} Preliminary; ^{r} Revised; ^{e} Estimated.

TABLE 3. WESTERN WORLD COUNTRIES, 1986 MINE CAPACITY AND UTILIZATION, AND 1988 FORECASTED CAPACITY

	1986 Capacity^{e}	1986 % Utilization[1]	1988 Capacity^{e}
	(tonnes W content)		
Canada	3 900^{r}	31	6 440
United States	4 575	20	2 500^{r}
Bolivia	3 500	43	3 550
Brazil	1 280	63	1 280
Austria	1 600	94	1 600
France	840	83	840
Portugal	1 570	76	1 570
Spain	460	53	460
Sweden	400	100	400
United Kingdom	75	..	75
South Africa	420	..	1 130
Japan	700	85	500^{r}
South Korea	2 800	71	2 800
Thailand	1 750	29	1 750
Turkey	1 000	10	1 000
Australia	3 400	30	3 400

Sources: Chase Econometrics World Ferroalloy Report, January 1984 Update, Tungsten; USBM Mineral Commodity Summaries, 1985; Energy, Mines and Resources Canada.
[1] Per cent utilization calculated.
^{e} Estimated; ^{r} Revised; .. Not available.

TABLE 4. WORLD PRODUCTION AND CONSUMPTION OF TUNGSTEN CONTAINED IN ORES AND CONCENTRATES, 1977-86, 1987 FORECASTED PRODUCTION AND CONSUMPTION OF TUNGSTEN CONTAINED IN ORES AND CONCENTRATES IN TONNES (t,W) AND AVERAGE ANNUAL WOLFRAM PRICE IN $US PER TONNE UNIT

Year	Production (t,W)	Consumption (t,W)	Surplus (Deficit) Annual (t,W)	Surplus (Deficit) Accumulated (t,W)	Wolfram Average Annual Price $US/t Unit
1977	40 681	35 888	4 793	4 793	170.67
1978	47 030	48 632	(1 602)	3 191	140.54
1979	47 872	51 217	(3 345)	(154)	139.07
1980	50 323	49 149	1 174	1 020	142.55
1981	48 701	47 095	1 606	2 626	143.20
1982	45 432	40 562	4 870	7 496	111.78
1983	38 310	40 770	(2 560)	4 963	81.16
1984	43 627	48 487	(4 860)	76	81.16
1985	4[illegible] 139	46 457	(3 318)	(3 142)	67.74
1986	36 596	44 075	(5 479)	(8 321)	41.40
1987^{e}	34 500	45 000	(10 500)	(19 221)	

Sources: United Nations Conference on Trade and Development, Committee on Tungsten, Tungsten Statistics, Metal Bulletin, Energy, Mines and Resources Canada.
^{e} Estimated.

Uranium

R.T. WHILLANS

In 1986, Canada maintained its position as the world's[1] leading producer and exporter of uranium. With over 30 new export contracts approved, Canada continued to play a major role in the international uranium market. Worldwide, uranium demand remains strong as installed nuclear capacity increases annually; during 1986, construction work proceeded at 157 nuclear reactor sites.

However, the uranium industry faces continued uncertainty as a result of developments during the year. A reassessment of nuclear power programs in the wake of the Chernobyl reactor accident in April could lead to downward adjustments to global uranium demand forecasts for the 1990s of the order of 5 per cent.

Of more concern is the outcome of court and legislative actions in the United States intended to limit the importation of foreign uranium for domestic use. Decisions in favour of the U.S. uranium mining industry could seriously disrupt international uranium trade. A ban on imports could lead to the development of two separate uranium markets, a repeat of the situation that occurred in the late-1960s and early-1970s. Under such a scenario, a seller's market could be created in the United States, with spot prices rising rapidly in the near term; elsewhere, spot prices would likely decline below the current depressed levels because of the availability of uranium originally intended for the U.S. market.

The market outlook was also complicated by the United States ban on South African uranium imports, introduced in late-1986 as an anti-apartheid gesture. At year-end it was uncertain whether this ban would apply to the importation of all South African uranium or only to that intended for domestic use, and what the probable impact would be.

It was announced in May that Australia's Olympic Dam project would go ahead. First production from the copper, gold and uranium operation was scheduled for mid-1988 at 1 600 tU/year.[1] The introduction of additional large quantities of uranium to an uncertain market may have further negative impact on prices, and could also affect the timing of the Cigar Lake project in Saskatchewan.

The provincial government of British Columbia announced in mid-December that it will lift the moratorium on uranium mining and exploration. Put in place in early-1980, the moratorium has reportedly had a dampening effect on the search for other minerals sometimes found in association with uranium. The moratorium will be allowed to expire as scheduled on February 28, 1987.

PRODUCTION AND DEVELOPMENT

In 1986, Canada's five primary uranium producers reported uranium concentrate production totalling 11 720 tU, which compares favourably with output in recent years (see Table 1). With project expansions completed now in Saskatchewan, annual Canadian production capability is expected to average over 12 000 tU through the late-1980s and remain close to this level in the early-1990s. Of Canada's total uranium shipments in 1986, some 60 per cent was attributable to the three Saskatchewan operations with the balance coming from the two Ontario producers at Elliot Lake (see Table 2). As domestic requirements are only about 15 per cent of current output, most of Canada's uranium production will be exported.

Ontario

Denison Mines Limited continues to match uranium production at Elliot Lake to requirements under long-term contracts. Milling is

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[1] World, used in the context of uranium supply, excludes the U.S.S.R., Eastern Europe and the People's Republic of China.

[1] tU = One metric ton (tonne) of elemental uranium (U), written as tU, is equivalent in terms of uranium content to 1.2999 short tons of uranium oxide (U_3O_8).

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restricted to the efficient, new semi-autogenous facility, permitting the shut down of the conventional crushing and grinding plant. Mid-year production totalled 1 023 tU, down 12 per cent from the same period in 1985. However, the year-end output target was reached in December. Mill recovery and grade of ore processed were maintained close to 1985 levels.

In September, operations began at Denison's $10 million joint venture project to recover yttrium oxide as a byproduct of uranium production. The new plant, adjacent to the existing Elliot Lake facilities, has an annual capability of more than 136 t of yttrium oxide or roughly 35 per cent of western world requirements. The facility was brought on-stream on schedule and within budget.

Rio Algom Limited experienced slightly reduced uranium revenues and earnings from its Elliot Lake operations during 1986, mainly due to lower uranium selling prices and decreased production. However, the on-going intensive cost control efforts should continue to offset these factors.

In late-April, Rio Algom and Ontario Hydro announced the renegotiation of their uranium supply agreement, whereby total deliveries from the Stanleigh operation over the period 1986 to 1993 will be reduced by 28 per cent; this is in addition to an earlier reduction of 15 per cent from 1983 to 2004. Although deliveries will be deferred until later in the contract period, total commitments under the agreement remain the same.

In an effort to reduce costs, the modified agreement provides for the exploitation of higher grade ore from adjoining properties (Nordic, Lacnor, and Milliken) not previously included in the contract. Rio Algom is assured continuity of its long-term contract and hence is provided an increased measure of stability; Ontario Hydro is now better able to rationalize its total uranium supply commitments in the early-1990s.

Saskatchewan

In June, Eldorado Resources Limited declared its new Collins Bay mine and the mill circuits at Rabbit Lake to be in commercial operation. The $100 million expansion program was designed to return the Rabbit Lake mill production capacity to 2 000 tU per year. Output for the year was expected to significantly exceed the 1985 production level.

Attention will now be directed at developing additional resources near Rabbit Lake, especially those discovered at Eagle Point. The high-grade and simple mineralogy of the Eagle Point ore lends itself to processing at the new Rabbit Lake mill circuit. As conventional mining methods are feasible, a single mining operation at Eagle Point may prove to be the most efficient and orderly development plan.

Cluff Mining achieved planned output levels for 1986 at Cluff Lake, although production to mid-year fell below target due to the processing of lower grade material from the Claude open-pit. The partnership is owned 80 per cent by Amok Ltd. and 20 per cent by Saskatchewan Mining Development Corporation (SMDC).

Cluff Mining is spending $2.6 million to modify its mill to reprocess accumulated radioactive waste to recover gold and uranium. These mill residues resulted from the processing of high-grade uranium ore during Phase I of the operation, and were placed in concrete vaults as an interim measure pending the selection of a final treatment solution. The plan, approved by the federal Atomic Energy Control Board and Saskatchewan's Department of the Environment, is designed to enhance worker safety, reduce environmental impact, and could earn the company a significant profit. Construction of the new reprocessing facility was ahead of schedule at year-end; operations are expected to begin in early-1987.

At the Key Lake mine, development of the Deilmann orebody proceeded ahead of schedule throughout 1986. Activities center on stripping the Deilmann pit area in preparation for mining in 1988; the smaller Gaertner pit was mined out by year-end 1986 although stockpiled ore will provide mill feed during the transition to Deilmann.

Operated by Key Lake Mining Corporation - jointly owned by SMDC (one-half), Uranerz Exploration and Mining Limited (one-third), and Eldor Resources Limited (one-sixth) - the project achieved record monthly production levels as the mill operated in excess of nominal design capacity. Annual output exceeded 4 600 tU in 1986 and is expected to remain at close to this level into the late-1990s.

As shown in Table 4, the workforce at Canada's primary uranium producing operations totalled some 5,330 employees as of

January 1986, a slight decline from previous years. Of this total, 2,370 worked in the mines, both open-pit and underground, and some 680 in the mills, with the balance described as general employees. Head office and construction-related employment is not included.

EXPLORATION

The Uranium Resource Appraisal Group (URAG) of Energy, Mines and Resources Canada, (EMR) completed its twelfth (1985) annual uranium supply assessment and exploration survey during 1986. EMR reported[1] that overall uranium exploration activity in Canada declined in 1985 for the sixth consecutive year. Responses to the 1985 URAG questionnaire indicated the exploration activities of all the major participants active in uranium exploration in Canada. Total expenditures reached $32 million in 1985, distributed among some 65 active projects.

The 10 operators[2] with the largest exploration budgets in 1985 accounted for 97 per cent of the $32 million total. In alphabetical order, they were: Amok Ltd., CEGB Exploration (Canada) Ltd., Cigar Lake Mining Corporation, Cogema Canada Limited, Eldor Resources Limited, Minatco Ltd., PNC Exploration (Canada) Co. Ltd., Saskatchewan Mining Development Corporation (SMDC), Uranerz Exploration and Mining Limited, and Urangesellschaft Canada Limited. As shown in Figure 1, foreign-based companies accounted for almost 65 per cent of overall expenditures in Canada in 1985, up from an average of 56 per cent over the previous four years. Although foreign involvement in uranium exploration in Canada is high and increasing, United States participation has been decreasing and in 1985 represented only 2 per cent of total expenditures.

Not all companies that responded to the 1985 URAG questionnaire had planned their exploration expenditures for 1986 at the time of the survey. However, from the preliminary estimate of $29 million, it appears that the decline in exploration expenditures has levelled off. The preliminary estimates for 1986 also reveal that drilling activity will be in the order of 142 000 m, a decrease of over 20 per cent from the effort in 1985.

As in the previous five years, virtually all the surface development drilling in 1985 was associated with major programs in the Athabasca Basin of Saskatchewan. Essentially no exploration drilling was done outside Saskatchewan, the Northwest Territories and Quebec. Figure 2 illustrates this concentration of effort for the period 1976 to 1985; during this time almost $600 million ($1985), or 55 per cent of the total uranium exploration outlay, was spent in Saskatchewan.

In late-1986, Cigar Lake Mining Corporation (CLMC) submitted a proposal to Saskatchewan's Department of the Environment for a $50 million underground exploration program, to study the feasibility of various mining methods that could be used to exploit the Cigar Lake deposit. The company was informed at the end of October that it must complete a full Environmental Impact Study in support of the proposal, and expects to have the necessary work completed in February 1987. If requisite environmental approvals are obtained during 1987, site preparation could then commence, with completion of the 490 m shaft in 1988 and test work by 1989-90.

The Cigar Lake orebody is the world's richest uranium deposit; the in-situ resources of the main mineralized pod grade 12 per cent U and exceed 100 000 tU. The joint venture partners are SMDC (50.75 per cent), Cogema Canada Limited (37.375 per cent), and Idemitsu Uranium Exploration Canada Ltd. (11.875 per cent).

During the year, Eldorado announced the results of its successful 1985/86 exploration drilling campaign. At the Eagle Point deposit, located within 12 km north of the Rabbit Lake mill, geologic uranium resources at Eagle North and Eagle South were reported by Eldorado to now exceed 50 000 tU, four times those of the Collins Bay "B" deposit.

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[1] "Canada Continues as World's Leading Uranium Producer" - News Release 86/138, Energy, Mines and Resources Canada, September 1986.

[2] An operator may incur expenditures on a project either alone or in a joint venture. In the latter case, the combined expenditure of all participants is attributed to the project operator; as such, contributions by other active parties not responding directly to the URAG survey are accounted for in the total.

URANIUM RESOURCES

The results of EMR's 1985 URAG uranium resource assessment, announced in a September 1986 News Release, are summarised in Table 6; the results of the 1984 assessment[1] are also shown for comparison. Quantities are presented in terms of uranium **recoverable from mineable ore** not uranium **contained in mineable ore.** Uranium resource estimates are divided by URAG into separate categories that reflect different levels of confidence in the quantities reported. These categories are further subdivided into three ranges of economic exploitability related to the price of uranium. For both the 1984 and 1985 assessments, the low price range (A) was assigned a uranium price limit of $100/kg U. The second (B) and third (C) price ranges spanned the $100-$150/kg U, and the $150-$300/kg U intervals, respectively. The price of $100/kg U was retained by URAG as being representative of those resources that were of economic interest to Canada in 1985. All quantities are reported in tonnes of elemental uranium, consistent with international practice. Prices are given in Canadian dollars/kg U[2].

In comparing the 1985 estimates with those of 1984 (see Table 6), the most significant change is the 19 per cent increase in measured resources, largely the result of continued uranium exploration and development work in northern Saskatchewan.

To provide an illustration of uranium availability in the short-term, two projections of Canadian production capability to 2000 were made, as illustrated in Figure 3. These scenarios indicate firm production capability based on existing production centres only, and assume levels of production that can be practically and realistically achieved. Only resources in the measured, indicated and inferred categories were incorporated into the projections.

The upper curve reflects production capability supported by resources recoverable at uranium prices of $150/kg U or less (i.e., A plus B price range), while the lower curve illustrates production capability supported only by resources recoverable at uranium price of $100/kg U or less (i.e., A price range). The two scenarios suggest that lower prices should not significantly affect Canadian production capability over most of the projection period.

The lives of existing production centres could be extended by the exploitation of known associated higher-priced resources, or by additions of resources discovered in the course of continued exploration and development work. No commitments have been made for the start-up of any production centres beyond those currently in operation.

The production capability scenarios are not intended to represent projections of actual output. Actual levels of production from these centres depend on a number of operational variables, and could be different from the capabilities projected. In addition, the probable start-up of the Cigar Lake operation in the mid-1990s would significantly reshape production capability projections.

UNITED STATES INITIATIVES

As a result of depressed uranium prices and delays in the United States nuclear power program, high-cost U.S. uranium producers have been unable to compete with lower-priced imports and many have been forced to discontinue operations.

U.S. uranium production has declined from the high levels of the mid- to late-1970s that were sustained, at high cost, by uranium import restrictions. Uranium concentrate production in 1985 totalled 4 350 tU compared with 16 800 tU in 1980. At the outset of 1986, only 4 mills at conventional uranium production centres were in operation; uranium from byproduct phosphoric acid production and from solution mining operations accounted for about 50 per cent of total United States output in 1985.

Throughout 1985 and 1986 the U.S. uranium industry exerted strong pressure to limit imports of uranium into the United States; the principal efforts focussed on three protective measures initiated through the courts and Congress.

The first is a lawsuit brought by the Uranium Producers of America (UPA) in 1985. Having established that in excess of one third of United States uranium requirements was being filled by non-U.S. uranium producers, the UPA claimed that existing U.S. legislation required the Department of

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[1] Uranium in Canada: 1984 Assessment of Supply and Requirements, Report EP 85-3, Energy, Mines and Resources Canada, September 1985.

[2] $1/lb U_3O_8 = $2.6/kg U.

Energy (DOE) to restrict the enrichment of foreign uranium until the domestic uranium industry was again "viable". The U.S. District Court in Denver, Colorado, agreed with the UPA and on June 20, 1986 ordered the DOE to terminate the enrichment of foreign uranium intended for domestic use, as of January 1987. The DOE appealed this court order, but the final decision had not been handed down by year-end. If upheld, this ruling would oblige some U.S. utilities to ship their foreign-sourced uranium to Europe for enrichment, and others to terminate existing foreign uranium contracts in order to buy U.S. uranium.

Second, over the past two years, Senator Domenici (New Mexico) introduced various legislative measures in support of U.S. uranium producers. The most recent initiative, to limit the use of foreign uranium by U.S. utilities to 50 per cent of requirements beginning in 1988, would seriously affect those utilities that have foreign uranium supply contracts for 50-100 per cent of their requirements. Although this legislation failed to pass before the adjournment of the Congress on October 10, 1986, it is expected to be reintroduced in 1987.

The third issue centres on Canada's further processing policy which requires Canadian uranium to be converted to uranium hexafluoride (UF_6) prior to export, as long as conversion capacity exists in Canada and is generally competitive. The policy is applied with flexibility however, as exemptions to the requirement can be obtained. The U.S. uranium processing industry submits that the Canadian policy constitutes a trade restriction, whereas Canada maintains that the policy is necessary because the world conversion market is not entirely open.

In support of the processing industry in his home state of New Jersey, Congressman Guarini introduced legislation in 1986 which would have placed an import tariff on UF_6 imported from "any country which has a further processing policy". This legislation also failed to pass through the Congress before the fall adjournment.

Continued pressure for protective measures can be expected during 1987 following the announcement in mid-December by U.S. Secretary of Energy, Herrington that the United States uranium mining and milling industry was not viable in calendar year 1985; the annual viability determination was also negative for 1984.

In October, the United States imposed a ban on South African uranium imports. However, in December the Treasury Department considered regulations that would allow the importation of South African uranium hexafluoride destined for re-export following enrichment in Department of Energy facilities. It remained uncertain at year-end how the ban would be finally interpreted and what its impact would be. That same month, Canada implemented controls, pursuant to the Export and Import Permits Act, on the importation of South African uranium. This action fulfilled a commitment made at the meeting of the Commonwealth heads of government, August 1986.

MARKETS AND PRICES

Canada's uranium producers continue to play an active role in the international uranium market. During 1986, some 30 new export contracts were reviewed and accepted by the federal government. As shown in Table 7, net additions resulting from new and revised contracts in 1986 brought to over 122 000 tU, the total amount of uranium under export contracts reviewed since September 5, 1974. The year-end 1986 total reflects scheduled deliveries under more than 160 contracts, about one-third of which remain active. As of December 1986, forward commitments under all active export contracts were estimated at 62 000 tU. Forward domestic commitments exceed 73 000 tU.

Actual exports in 1985 approached 8 300 tU, and were primarily to Japan and the United States (see Table 8). Japan continues to be Canada's most important single customer, accounting for over one-third of Canada's scheduled deliveries since the beginning of the commercial contract era. Most of the remaining exports have gone to the European Economic Community (30 per cent), the United States (20 per cent), and other countries in western Europe (13 per cent). The future importance of these Canadian markets can be illustrated in terms of scheduled deliveries as shown in Figure 4.

The average price of export deliveries made by Canadian producers in 1985 was $Cdn 91/kg U. The spot market continues to have a definite impact on the average price, as about 20 per cent of export deliveries in 1985 were under spot sales, compared with 25 per cent in 1984, 10 per cent in 1983 and only 1.5 per cent in 1982.

Compared to the average export price reported above, uranium spot market prices were significantly lower, as reflected by the Nuclear Exchange Corporation's[1] (Nuexco) monthly exchange value[2] (EV). The EV rallied from $US 15/lb U_3O_8 in January 1985 to $US 17 in December; it failed to remain above this level, holding at $US 17 through much of 1986, and dipped to $US 16.75/lb U_3O_8 at year end.

REFINING

Eldorado Resources Limited operates Canada's only uranium refining and conversion facilities.

At the Blind River, Ontario, plant, uranium concentrates from mines in Canada and other countries are refined to high purity uranium trioxide (UO_3)[3]. The UO_3 is then converted at Port Hope, Ontario, into either uranium hexafluoride (UF_6)[4] prior to enrichment for foreign utilities that operate light water reactors, or ceramic-grade uranium dioxide (UO_2) for CANDU-type heavy water reactors that use natural uranium.

In 1985, Eldorado processed mine concentrates containing over 6 800 tU, setting a 10-year record with a 55 per cent increase from 1984. Production of UO_2 has returned to normal levels after declining in 1984 as a result of the shutdown for repairs of two Ontario Hydro CANDU reactors at Pickering. With the completion of its new UF_6 plant, Eldorado closed the original facility; it will remain available for future use as the UF_6 conversion market grows.

NUCLEAR POWER DEVELOPMENTS

Despite the slow rate of new reactor orders in the world, the number of operating reactors will continue to grow steadily into the 1990s. Construction work started on six new plants in 1985, the first year since 1973 without any cancellations of orders or suspensions of construction. The International Atomic Energy Agency (IAEA) reported that as of January 1, 1986, 374 nuclear power reactors, with a combined generating capacity of some 250 electrical gigawatts (GWe)[1], were on-line in national grids in 32 countries. A further 157 reactors with a combined capacity of 142 GWe were under construction at the beginning of 1986.

In Canada, 18 CANDU reactors with an aggregate net output capacity of some 11 000 electrical megawatts (MWe) were in service (i.e., commercially operable) at year-end 1986 and a further 5 reactors with an additional capacity of some 4 400 MWe were either in the pre start-up phase or under construction (see Table 11). Nuclear generation in Canada reached 57 TWh[2] in 1985, an increase of some 16 per cent from 1984; it accounted for 13 per cent of total Canadian electricity generation.

In July, an Ontario government Select Committee on Energy studying the future of the four-reactor Darlington Nuclear Generating Station recommended that the plant be completed; the following month the Ontario Cabinet accepted the Committee recommendations. Canada's commitment to nuclear power remains firm.

Ontario Hydro's nuclear reactors maintained their standing among the world's best performers. To the end of 1985, 5 of Hydro's 13 in-service CANDU's were in the top 10 in terms of lifetime capacity factor[3] out of 212 commercial power reactors, rated at 500 MWe or greater, in service around the world.

Some 40 per cent of the total electrical energy generated by Ontario Hydro during 1985 came from nuclear-electric units, 34 per cent from hydro-electric sources and 26 per cent from coal-fired plants.

At Ontario Hydro's four-reactor Pickering 'B' Nuclear Generating Station (NGS) east of Toronto, unit 8 was declared in service on February 28, 1986.

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[1] A California-based uranium brokerage firm.

[2] Nuexco's judgement of the price at which transactions for significant quantities of natural uranium concentrates could be concluded as of the last day of the month.

[3] Uranium trioxide is the initial refined product from which UO_2 or UF_6 is produced.

[4] Uranium hexafluoride is the required feed material for the uranium enrichment process.

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[1] GWe = 10^9 watts.

[2] Terawatts-hours = 10^{12} watt-hours.

[3] Lifetime capacity factor is the ratio of electricity produced, from the in-service date of the reactor, relative to that which could have been produced had the reactor operated at 100 per cent power input for 100 per cent of the time.

Units 5 and 7 of the Bruce 'B' NGS near Kincardine, were declared in service on March 1, 1985, and April 10, 1986, respectively; unit 8 is expected to enter service on January 1, 1987.

At Ontario Hydro's Darlington NGS near Bowmanville, construction schedules are being maintained. The most probable in-service dates for units 1 to 4 are February 1989, May 1988, November 1991 and August 1992, respectively.

In New Brunswick, Canada's first 600 MWe series CANDU reactor continues to operate exceptionally well. The Point Lepreau I unit, located 40 km southwest of Saint John, operated at close to full capacity throughout most of 1985 and 1986, producing one-third of the provincial electricity supply.

Hydro-Quebec's Gentilly 2 Nuclear Power Station near Bécancour, Canada's second 600 MWe CANDU to go into service, also continues to perform well.

OUTLOOK

In the next few years, the requirements for Canadian uranium will depend largely upon two factors. One is continued access to the U.S. market, which accounts for more than half of the western world's unfilled uranium requirements between 1986 and 1990. The other factor is the continued growth of nuclear power capacity in Canada and its trading partners. Nuclear energy is making a significant and increasing contribution to electricity requirements in many countries. This installed and committed nuclear capacity will require increasing supplies of uranium well into the next century.

The IAEA reported that total installed nuclear power capacity in the world grew by more than 30 per cent during 1984/85. Nuclear plants now account for around 15 per cent of the world's total electrical generation. By the year 2000, the total uranium requirement in OECD countries alone is expected to exceed 60 000 tU, significantly more than current world[1] production.

Canada replaced the United States as the leading world producer of uranium in 1984 and maintained that lead in 1985, accounting for about 30 per cent of total output, estimated in excess of 35 000 tU.[1] Canada's position as the world's leading producer and exporter of uranium is expected to be maintained for several years to come.

Annual uranium production capability in Canada should average about 12 000 tU through the 1990s. The uncertain outlook for the uranium market over the next few years may postpone the initiation of further new domestic production projects until the mid- to late-1990s.

The outcome of the U.S. court and Congressional actions, the disposition of surplus consumer inventories, the growth in uncommitted demand, the introduction of significant quantities of co-product uranium from Olympic Dam into an uncertain market and the impact of these factors on uranium prices will determine the actual level of production achieved in Canada; output may well fall below the full 12 000 tU per year capability.

As 1986 drew to a close, it was clear that the political/protectionist manoeuvering in the United States was the most critical issue facing Canada's uranium industry. Canada would be very concerned if actions were successful in restricting exports of Canadian uranium to the United States, especially during the "Free Trade" talks aimed at halting protectionism in cross-border commerce. Both countries benefit from substantial two-way trade.

It is hoped that this issue will be resolved and that Canada will remain free to compete openly in the international uranium market. Canada has the capability to satisfy its own needs while maintaining its place as the leading supplier of uranium to world markets.

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[1] "World", used in the context of uranium supply, excludes the U.S.S.R., Eastern Europe and the People's Republic of China.

[1] "Uranium: Resources, Production and Demand", 1986, the biennial 'Red Book' report jointly produced by the Nuclear Energy Agency of the Organization for Economic Co-Operation and Development, and the International Atomic Energy Agency.

TABLE 1. URANIUM PRODUCTION IN CANADA, BY COMPANY, 1984 and 1985

Company	Location	Production	
		1984	1985
		(tonnes U[1])	
Cluff Mining (Amok Ltd./SMDC)	Cluff Lake, Sask.	642	834
Denison Mines Limited	Elliot Lake, Ont.	2 246	2 112
Eldorado Resources Limited	Rabbit Lake, Sask.	1 361	824
Key Lake Mining Corporation	Key Lake, Sask.	4 003	4 270
Rio Algom Limited - Quirke	Elliot Lake, Ont.	1 372	1 328
- Panel		841	827
- Stanleigh		704	685
Total Canada[2]		11 169	10 880

Source: Company annual reports.

[1] One metric ton (tonne) of elemental uranium (U), written as tU, is equivalent in terms of uranium content to 1.2999 short tons of uranium oxide (U_3O_8). [2] Primary uranium production only; does not include uranium recovered from refinery raffinates and sludges by Rio Algom Limited and Denison Mines Limited.

TABLE 2. VALUE OF URANIUM SHIPMENTS[1] IN CANADA BY PROVINCE, 1984-86

	1984		1985		1986P	
	(t)	($000)	(t)	($000)	(t)	($000)
Ontario	4 552	544,779	4 499	552,561	4 445	476,462
Saskatchewan	5 720	356,794	5 942	449,566	6 532	447,376
Total	10 272	901,573	10 441	1,002,127	10 977	923,838

[1] Shipments of uranium (U) in concentrate from ore processing plants.
P Preliminary.

TABLE 3. OPERATIONAL CHARACTERISTICS OF CANADIAN URANIUM PRODUCTION CENTRES IN 1985

Company Name/ Production Centre	Nominal Mill Capacity/Actual Throughput (tpd)	Total Ore Processed (t)	Average Grade of Ore Processed (kg U/t)	Overall Mill Recovery (%)
Cluff Mining/ Cluff Lake	800 in Phase II	233 370	3.68	97
Denison Mines Limited/ Elliot Lake	13 610 / 8 160	2 667 400	0.81	93
Eldorado Resources Limited/Rabbit Lake	1 800 / 1 900	403 570	2.21	94
Key Lake Mining Corporation/Key Lake	700 / 550^{e}	194 500	23.00	95
Rio Algom Limited/ Elliot Lake				
- Quirke	6 350 / 5 190	1 723 500	0.83	94
- Panel	2 990 / 3 030	988 030	0.88	95
- Stanleigh	4 540 / 3 630	1 157 900	0.65	93

Sources: Corporate Annual Reports and the Atomic Energy Control Board (AECB).
^{e} Estimated.

TABLE 4. WORK FORCE SUMMARY - CANADIAN URANIUM PRODUCING OPERATIONS

Company Name (Mine Name)	Total Number of Employees (Mine, Mill, General) 1/1/84	1/1/85	1/1/86
Cluff Mining (Cluff Lake)	272	309	281
Denison Mines Limited (Denison)	2,199	2,200	1,870
Eldorado Resources Limited (Rabbit Lake)	337	319	340
Key Lake Mining Corporation (Key Lake)	489	427	413
Rio Algom Limited (Quirke)	1,079	1,069	1,026
(Panel)	678	669	685
(Stanleigh)	789	818	718
Total all producers	5,845	5,811	5,333

TABLE 5. PRODUCTION OF URANIUM IN CONCENTRATES BY MAJOR PRODUCING COUNTRIES, 1981-85

	United States	Canada	South Africa	Namibia	France	Niger	Gabon	Australia	Other	Total[1]
					(tonnes U)					
1981	14 800	7 720	6 130	3 970	2 560	4 360	1 020	2 920	670[2]	44 150
1982	10 330	8 080	5 820	3 780	2 860	4 260	970	4 420	970[2]	41 490
1983	8 140	7 140	6 060	3 720	3 270	3 470	1 040	3 210	900[2]	36 950
1984	5 720	11 170	5 740	3 690	3 170	3 400	1 000	4 390	950[3]	39 230
1985	4 350	10 880	4 880	3 600	3 200	3 180	940	3 250	900[e]	35 180

Sources: Data derived principally from "Uranium: Resources, Production and Demand," 1986, a biennial report jointly produced by the Nuclear Energy Agency of the Organization for Economic Co-operation and Development, and the International Atomic Energy Agency; supplements from the 1985 "MINEMET" report of Imétal S.A., and from miscellaneous sources. Country totals are rounded to the nearest 10 tU.

[1] Totals (rounded) are of listed figures only. [2] Includes Argentina, Belgium, Brazil, Federal Republic of Germany, India, Israel, Japan, Portugal and Spain. [3] Includes Yugoslavia.
[e] Estimate.

TABLE 6. ESTIMATES[1] OF CANADA'S URANIUM RESOURCES RECOVERABLE FROM MINEABLE ORE[2], 1984 AND 1985

Price ranges within which mineable ore is assessed[3]	Reasonably Assured Resources				Estimated Additional Resources - Category I	
	Measured		Indicated		Inferred	
	1985[4]	1984[4]	1985[4]	1984[4]	1985[4]	1984[4]
(Canadian dollars)			(000 tonnes U)			
A	41	31	119	124	103	105
B	-	-	72	59	100	92
A + B	41	31	191	183	203	197
C	23	23	33	50	54	67
A + B + C	64	54	224	233	257	264

[1] Interim revisions for 1985; comprehensive assessments for selected properties only. [2] Losses in mining recovery as well as ore processing have been accounted for. [3] The price figures reflect the price of a quantity of uranium concentrate containing 1 kg of elemental uranium. The prices were used in determining the cut-off grade at each deposit assessed, taking into account the mining method used and the processing losses expected. [4] For the 1985 and 1984 assessments the price ranges were (A) $100/kg U or less, (B) between $100 and $150/kg U, and (C) between $150 and $300/kg U.
- Nil.

TABLE 7. URANIUM UNDER EXPORT CONTRACTS REVIEWED[1] SINCE SEPTEMBER 5, 1974

Country of buyer	1986 (tonnes U)
Belgium	3 330
Finland	3 510
France	9 617
Italy	1 120
Japan	25 048
South Korea	5 140
Spain	3 556
Sweden	8 473
Switzerland	150
United Kingdom	7 700
United States	40 990
West Germany	14 330
Total	122 964

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[1] Reviewed and accepted under Canadian uranium export policy. Totals adjusted to reflect new and amended contracts as of December 31, 1986.

TABLE 8. EXPORTS OF URANIUM OF CANADIAN ORIGIN

Country of Final Destination	Tonnes of contained uranium[1]			
	1982	1983	1984	1985
Belgium	85	-	121	157
Finland	96[r]	179	137	64
France	-	435	525	661
Italy	143	-	50	53
Japan	718	663	2 436	1 799
South Korea	74	94	30	194
Spain	110	-	-	-
Sweden	889	613[r]	254	514
United Kingdom	379	675[r]	692	691
United States	4 852[2]	860[r]	2 397	3 892
West Germany	471	490	295	269
Total	7 817[r]	4 009[r]	6 937	8 294

Source: The Atomic Energy Control Board.

[1] Some of this uranium was first exported to intermediate countries, namely France, United States and U.S.S.R., for enrichment and then forwarded to the country of final destination. [2] The bulk of this material represents uranium exchanged by Eldorado in the purchase of the Rabbit Lake operation.

[r] Revised; - Nil.

TABLE 9. EXPORTS[1] OF RADIOACTIVE ORES AND CONCENTRATES[2] FROM CANADA, 1977-85

	United States[3]	U.S.S.R.	United Kingdom	Italy	West Germany	France	Nether-lands	Japan	Norway	South Korea	Total
						($000)					
1977	72,848	-	2,590	-	-	-	-	-	-	-	75,438
1978	163,911	-	39,106	3,348	-	-	-	791	-	-	207,156
1979	347,388	-	18,851	12,613	-	-	-	9	-	-	378,862
1980	218,013	-	10,319	-	-	1	-	-	-	2,329	230,662
1981	152,473	3,182	18,845	-	-	-	-	-	2,862	2,022	179,384
1982	346,891	-	11,690	-	-	-	-	-	-	-	358,581
1983	25,400	-	37,175	-	-	-	-	-	-	-	62,575
1984	295,686	-	28,188	2	6,149	36	167	3,475	-	-	333,701
1985	98,066	-	23,446	-	1,823	4,418	-	104,123	-	-	231,896

Source: Statistics Canada.
[1] Material that cleared Canadian customs with destination as indicated. [2] Includes uranium in concentrates. [3] Prior to 1977, uranium almost entirely destined for transshipment, primarily to western Europe and Japan, following conversion and enrichment; for subsequent years, figures represent a mixture of sales to United States and others, primarily in western Europe and Japan.
- Nil.

TABLE 10. EXPORTS[1] OF RADIOACTIVE ELEMENTS[2] AND ISOTOPES FROM CANADA, 1977-85

	United States[3]	U.S.S.R.[4]	United Kingdom	West Germany	France	Belgium/ Luxembourg	Nether-lands	Finland	Argentina	Japan	South Korea	Other	Total
							($000)						
1977	151,869	6,133	356	384	685	75	-	10	287	288	-	1,078	161,165
1978	269,903	101,619	38,602	6,918	19,046	23	-	10	12,177	1,017	-	1,668	450,983
1979	293,577	170,500	5,147	26,159	1,762	221	629	5,493	94,038	1,101	87	3,363	602,077
1980	199,001	77,235	2,104	20,406	144,013	4,847	374	6,408	27,766	1,911	137,002	4,312	625,379
1981	382,418	20,192	2,081	40,092	213,051	339	7,506	-	248	1,577	67	2,915	670,486
1982	299,246	34,854	796	37,250	36,213	291	45r	199	214	19,617	123	5,185r	434,033
1983	261,168	8,148	2,303	32,208	39,037	232	1,517	11	315	12,371	3,057	7,248	367,615
1984	416,670	-	1,601	14,364	28,988	71	598	20,128	520	35,729	8,311	13,720	540,700
1985	433,142	-	22,156	3,860	77,492	6	702	5,437	1,305	35,775	150	9,793	589,818

Source: Statistics Canada.
[1] Material that cleared Canadian customs with destination as indicated. [2] Includes uranium hexafluoride (UF_6) and radioisotopes for medical and industrial purposes. [3] Prior to 1977, UF_6 component destined for transshipment, primarily to western Europe and Japan, following enrichment; for subsequent years, figures would also include UF_6 sales to the U.S. market. [4] UF_6 component destined entirely for transshipment to western Europe, following enrichment.
- Nil; r Revised.

TABLE 11. NUCLEAR POWER PLANTS IN CANADA

Reactors	Owner	Net Output (MWe)	In-Service Dates (Expected)
Nuclear Power Demonstration	Atomic Energy of Canada Limited	22	1962
Pickering 1 to 4	Ontario Hydro	2 060	1971-73
Bruce 1 to 4	Ontario Hydro	3 056[r]	1977-79
Point Lepreau	New Brunswick Electric Power Commission	635	1983
Gentilly 2	Hydro-Quebec	638	1983
Pickering 5 to 8	Ontario Hydro	2 064	1983-86
Bruce 6, 5 and 7	Ontario Hydro	2 507	1984-86
Bruce 8	Ontario Hydro	837	1987
Darlington 1 to 4	Ontario Hydro	3 524	(1988-92)
Total		15 343	

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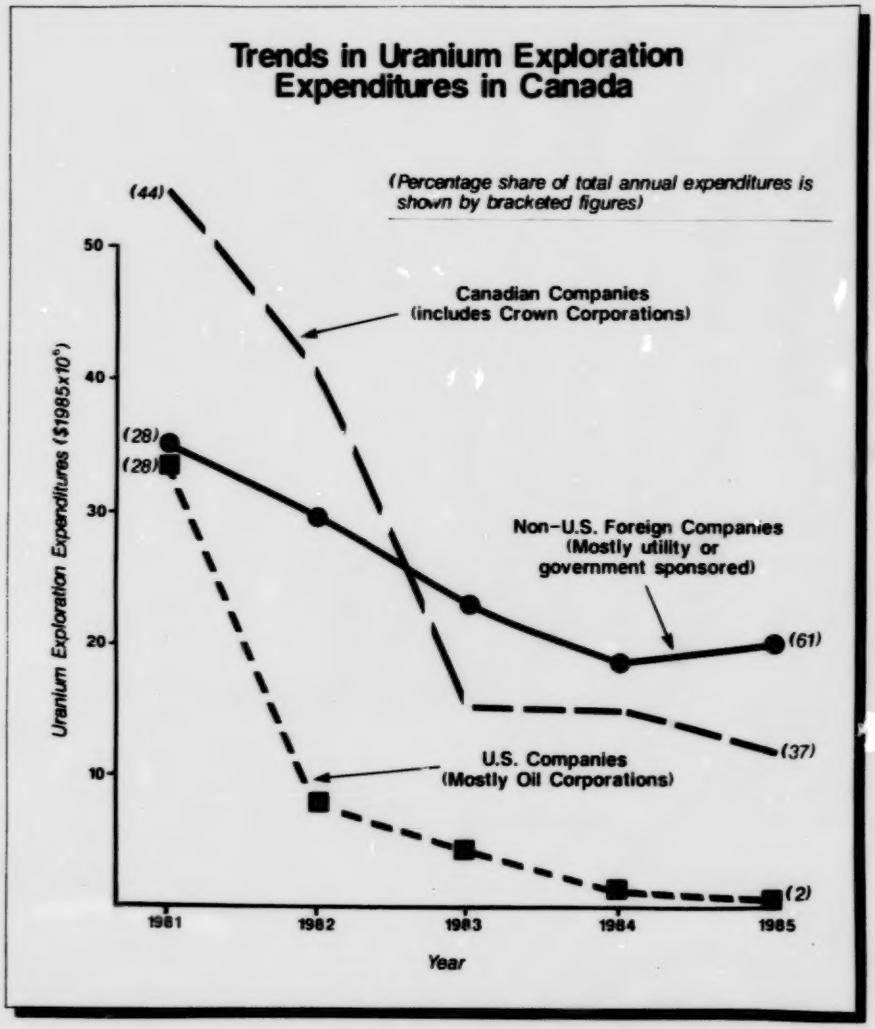
[r] Re-rated.

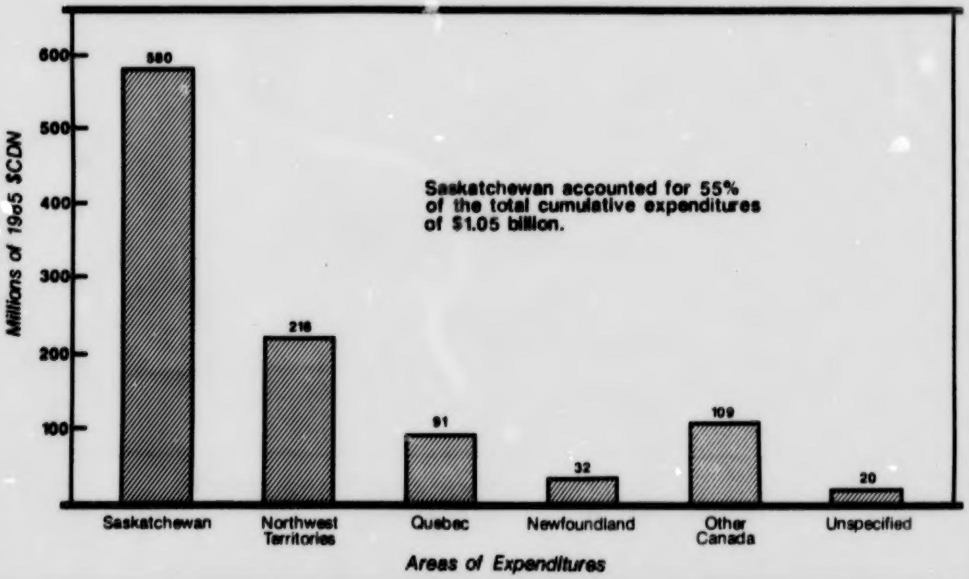
FIGURE 1



Trends in Uranium Exploration Expenditures in Canada

(Percentage share of total annual expenditures is shown by bracketed figures)

FIGURE 2



Uranium Exploration Expenditures in Canada

Cumulative values–1976 to 1985 Inclusive

Saskatchewan accounted for 55% of the total cumulative expenditures of $1.05 billion.

FIGURE 3

Canadian Uranium Production Capability

compared with

Domestic Reactor Requirements

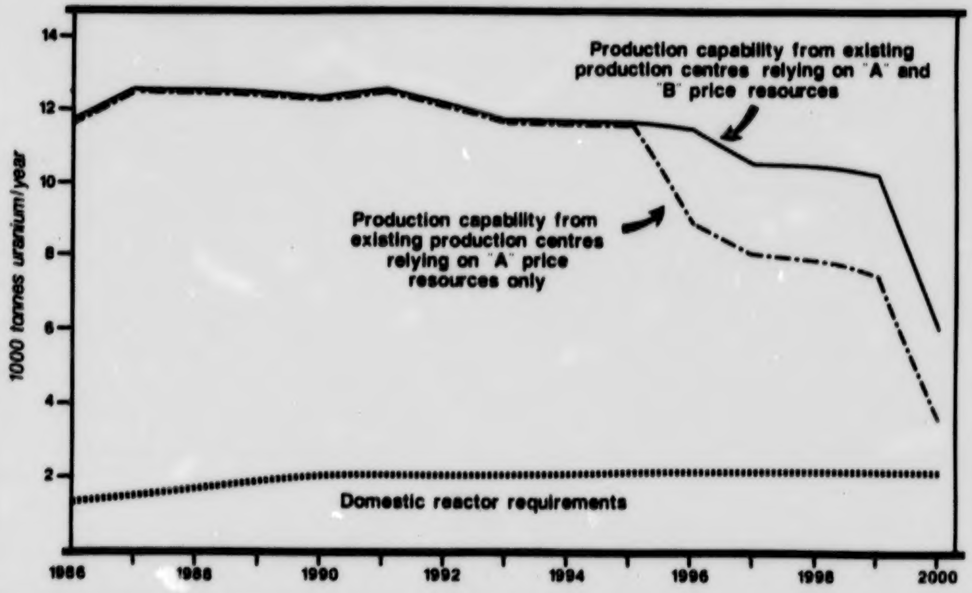
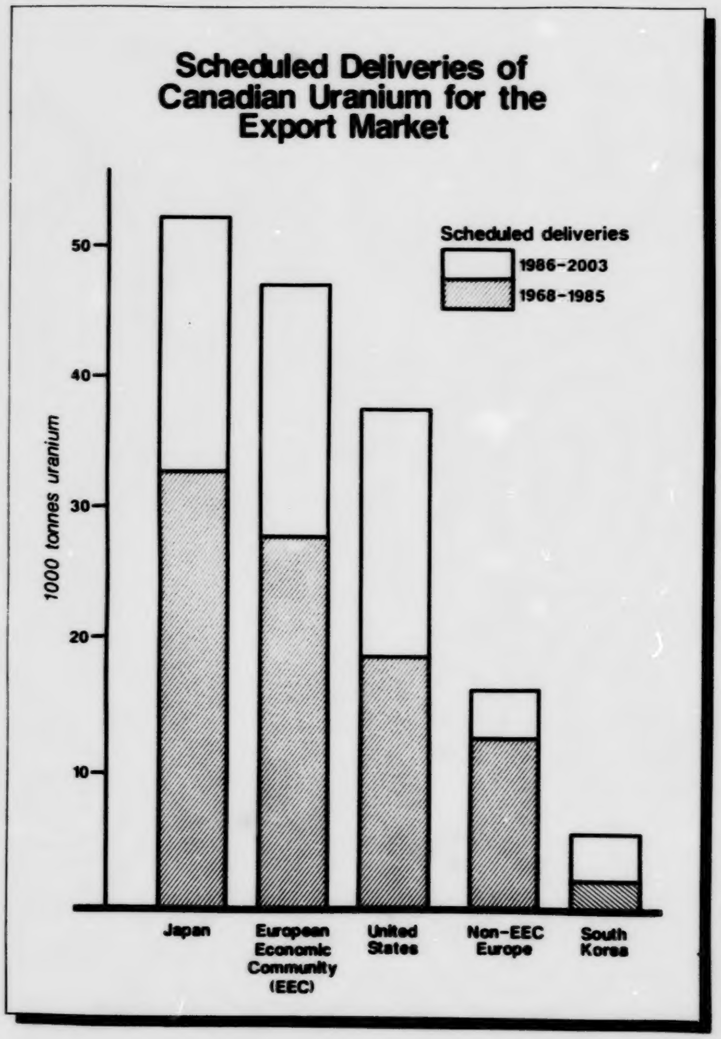


FIGURE 4



Scheduled Deliveries of Canadian Uranium for the Export Market

Zinc

M.J. GAUVIN

The pace of economic growth in the western world was sluggish in 1986 compared with the earlier years of economic expansion which began in 1982. However, zinc consumption in 1986 increased by over 3 per cent from that in 1985 but metal production declined, resulting in decreased inventories and a close balance between supply and demand. This, plus production interruptions, contributed to a steady increase in prices over the year.

The outlook for the next year or two is for modest consumption growth. Producers therefore will have to continue to restrain production to keep supply in balance with demand.

CANADIAN DEVELOPMENTS

Not unlike the industry around the world, there was considerable restructuring and reorganizing of the Canadian mining industry during the year. Among the key developments was the acquisition by Falconbridge Limited, early in the year, of Kidd Creek Mines Ltd. from Canada Development Corporation. A change in control of Canada's largest zinc producer occurred when Canadian Pacific Limited sold a major interest (31 per cent) in Cominco Ltd. to a consortium consisting of Teck Corporation (50 per cent), M.I.M. (Canada) Inc. (25 per cent) and Metallgesellschaft Canada Limited (25 per cent). Late in the year, Kerr Addison Mines Limited, one of the Noranda Group of companies, bought Falconbridge's 50.4 per cent interest in Corporation Falconbridge Copper. Also, an Australian company, East-West Minerals NL, acquired ownership of Anaconda Canada Exploration Ltd. and Caribou-Chaleur Bay Mines Ltd. This may lead to the early development of the Caribou deposit in New Brunswick, which has over 6 million t of estimated mineable reserves averaging 9.5 per cent zinc, 4.5 per cent lead, 0.35 per cent copper, 1.6 g/t gold and 124 g/t silver.

Canadian zinc mine production in 1986 was 1.29 million t compared with 1 172 238 t in 1985.

Newfoundland Zinc Mines Limited at Daniel's Harbour, Newfoundland, suspended operations indefinitely on April 14 because of low zinc prices. The mine was maintained in standby condition should conditions justify resumption of operations, but at year-end it remained closed. In New Brunswick, after a two week shutdown of its mine and lead smelter in December 1985, Brunswick Mining and Smelting Corporation Limited closed its mine for two weeks and the smelter for three weeks during July. The shutdowns were for market reasons and necessary maintenance.

Noranda Inc. announced that it will develop its recently discovered Isle Dieu orebody near its Mattagami mine in Quebec. It is expected that production will start in late-1988 with the ore to be milled at the Mattagami mill. The mine will have a capacity of 50 000 tpy of zinc in concentrate and has ore reserves estimated at 2.1 million t grading 22.4 per cent zinc, 1.23 per cent copper, and 87 g/t silver. The ore will replace declining Mattagami production. Near Joutel, Quebec, BP Canada Inc. completed the development of the A1-Zone of Les Mines Selbaie and started processing the ore in the expanded 6 500 tpy mill in late-October. Annual production of zinc from the new open-pit mine is expected to be 30 000 t of zinc in concentrates. Near Noranda, Quebec, Noranda Inc. suspended production early in the year at the Gallen mine.

Corporation Falconbridge Copper announced that it is proceeding with the development of the Winston Lake zinc-copper deposit in northwestern Ontario. The mine is planned to begin production in early-1988 with a capacity of 57 500 tpy of zinc in concentrates. Ore reserves at the property are estimated at 2.2 million t grading 18 per cent zinc, 1.1 per cent copper and significant precious metal values.

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Pine Point Mines Limited embarked on an accelerated mining plan for 1986 and 1987. Excess concentrate production will be stockpiled for processing at Trail in future years. Cominco Ltd. also instituted extended summer shutdowns at the Sullivan mine, the Polaris mine and the Trail metallurgical complex. Westmin Resources Limited, because of a three-fold increase in production at its new Myra Falls, H-W mine-mill complex and improved efficiency, saw its operating costs cut almost in half. Curragh Resources Corporation reopened the Faro, Yukon property in June and started operating at capacity shortly thereafter. The property had been closed by its previous owner, Cyprus Anvil Mining Corporation, in 1982.

Refined zinc production in Canada, estimated at 570 596 t, down substantially from the 692 406 t produced in 1985. This drop is accounted for by summer shutdowns at several smelters and a five month strike at the Valleyfield, Quebec, plant of Canadian Electrolytic Zinc Limited. Falconbridge Limited completed the expansion of the Kidd Creek zinc plant at Timmins, Ontario, from 127 000 tpy to 133 000 tpy. Hudson Bay Mining and Smelting Co., Limited, recognizing the need to modernize its smelter, is considering new technology including a pressure-leach facility.

WORLD DEVELOPMENTS

Mining

Non-socialist world zinc mine production in 1986 is estimated at 5.15 million t, an 0.8 per cent increase from the 5.11 million t produced in 1985. The small increase in production was accounted for mainly by higher output in Canada, which more than offset small decreases in most other producing countries.

Mine production in the United States fell by some 40 000 t during 1986, the sixth successive year of decline. Production was lower as a result of labour disputes, the temporary closure of ASARCO Incorporated's four Tennessee mines and the suspension of production at two other mines. Cominco American Incorporated, in partnership with the Nana Regional Corp. (an Alaskan native company), is planning the development of the Red Dog mine in Alaska. Located some 100 km from the Chukchi Sea, ore reserves are estimated at 85 million t averaging 17.1 per cent zinc, 5.0 per cent lead and 82 g/t of silver. It will be operated and financed by Cominco, but after the investment is recovered the partners will share proceeds on a 50:50 basis. The Alaskan Legislature has passed a bill authorizing the Alaska Industrial Development Authority to issue up to $175 million in bonds to finance construction of a road and port for the project. Road construction is planned to start in 1987. The mine, which is expected to be in production in 1991, could have a life of 50 years and become the world's largest zinc producer.

Mexico's zinc production remained unchanged from that of 1985. Industrial Minera Mexico S.A. completed the 18 000 t expansion of its Charcas mine. In Honduras, Rosario Resources Corporation is expanding its El Mochito mine from 49 000 to 64 000 tpy of zinc starting in 1987. Production in Peru, still plagued by strikes, stayed at about the same level as in 1985. Expansions at two mines were completed, adding 21 000 tpy to capacity, and two large projects are on the drawing board for the 1990s.

Outokumpu Oy, the state owned Finnish mining company, acquired the majority shareholding in Tara Mines Ltd. in Ireland by buying control of Tara Exploration and Development Company Limited. Tara owns the large Naven zinc-lead mine which has an output of some 200 000 tpy of zinc and 40 000 tpy of lead in concentrates. In another change of ownership, Boliden AB of Sweden has taken control of the Black Angel mine at Marmorilik, Greenland, from Vestgron Mines Limited, a subsidiary of Cominco Ltd. It is expected that production will continue at the Black Angel mine, which opened in 1973, until the ore is mined out, possibly during 1988.

Production cutbacks at the Bad Grund and Rammelsberg mines of Preussag AG Metall, because of unfavourable market conditions, limited production in Germany. The closure of one mine reduced Italy's production in 1986, but, the expansion of the Monteponi mine in Sardinia, to be completed in 1987, will add 42 000 t to Italy's mine capacity. The opening of the Troya zinc-lead mine in Spain in late-1986 added 31 000 t to that country's capacity.

Australia's mine production was down marginally from 1985, mainly due to labour disputes at the mines in the Broken Hill area. The Woodcutters open-pit mine started production in 1985 and will shift into underground mining of the orebody in 1987. The large Hellyer deposit of Aberfoyle Limited (Cominco Ltd., 47 per cent owner) and Paringa Mining and Exploration Co. plc in Tasmania is now the subject of a feasibility study to determine at what rate it should be brought into production. Exploration and development work are proceeding on several large zinc-lead deposits which could lead to decisions by the end of the decade to bring them into production. Hindustan Zinc Ltd. is considering bringing the large Rajpura-Agucha zinc deposit into production to produce 70 000 tpy of zinc in concentrates in the early-1990s. In Japan, three small mines with a total capacity of 12 000 tpy of zinc in concentrates ceased operating during the year.

Smelting and Refining

Non-socialist world zinc metal production was estimated at 4.87 million t in 1986, down slightly from the 4.97 million t produced in 1985. Reduced output in Canada, United States, Japan and Peru more than offset increases in Australia, Italy and other countries.

In the United States, an accident at the secondary zinc refinery of Huron Valley Steel Corp. forced the closure of the plant. Production at the 80 000 tpy Sauget, Illinois zinc plant of AMAX Inc. was reduced because of a 36-day strike during the year. In Mexico, Zincamex S.A. closed its 30 000 tpy horizontal retort plant at Saltillo.

Norzink A/S completed a 20 000 t expansion of its Odda, Norway electrolytic plant, raising its capacity to 110 00 tpy. In Spain, Asturiana de Zinc S.A. cut zinc output starting in May from 15 000 to 11 000 t a month due to low market prices. Asturienne-France SA continued work on the expansion of its Auby, France electrolytic plant from 100 000 to 200 000 tpy. It is scheduled to be completed in early-1988, but this will be balanced by the closure of its 110 000 tpy plant at Viviez, France.

In Brazil, the electrolytic plant at Itaquoi has been expanded from 15 000 to 27 000 tpy. In India, Cominco Binani Zinc Limited plans completion in 1987 of a new 20 000 tpy electrolytic plant to replace its existing 14 000 t plant, and Hindustan Zinc Ltd. is considering the construction of a 70 000 t ISF plant for start-up in the early-1990s. Japanese smelting companies closed indefinitely two small zinc distillation plants and one large vertical retort plant, taking 126 000 tpy capacity out of operation, while in the Republic of Korea, Korea Zinc Co. Ltd. completed the expansion of its Onsan electrolytic plant from 70 000 t to 150 000 tpy.

CONSUMPTION

World zinc metal consumption in 1986 is estimated at 4.88 million t, up 3.6 per cent from the 4.71 million t consumed in 1985. Should this estimate be confirmed, consumption in 1986 for the first time will equal the non-socialist world peak reached in 1973.

PRICES

At the beginning of 1986, the producer price of high-grade zinc was 34.5 cents (U.S.) a pound in the United States and 47 cents (Cdn.) in Canada, while the European Producer Price (EPP) was $US 700 a tonne. Prices declined during February to 32 cents in the United States and $670 for the EPP, then gradually increased to the year's high in October. The prices then were 50 cents in the United States, 69.5 cents in Canada and $920 for the EPP. Price reductions in late-November brought the high-grade zinc price at year-end down to 44 cents a pound in the United States, 61 cents a pound in Canada and $870 for the European Producer Price.

USES

Zinc is a widely used metal, based on its low melting point which facilitates shaping by casting; its high electrochemical activity which provides cathodic corrosion and contact protection (galvanizing) for iron and steel products; and its ability to alloy readily with copper to make brass. About 40 per cent of zinc is used in galvanizing. Galvanized products such as main structural components, roofing, siding and reinforcing bars are used in construction. Brass and bronze, as used in products such as plumbing fittings and the heating industry, account for about 20 per cent of zinc consumption. Some 15 per cent of zinc consumption is in the diecasting industry for products such as builders' hardware and fittings on automobiles. The balance is used for such items as zinc semi-manufactures, chemicals and dust.

The first copper-plated zinc penny was struck by the U.S. Mint in November 1981 and placed in circulation in January 1982. The penny blanks are made of an alloy containing 99.2 per cent SHG zinc and 0.8 per cent copper; the total penny including plating is 97.6 per cent zinc and 2.4 per cent copper. This new usage for zinc has been consuming about 30 000 to 35 000 tpy of zinc. Although reported to be down somewhat in 1986, it is expected to be over 40 000 t in 1987. The results of regular tenders for zinc conducted by the Mint are looked upon by many as a barometer of the zinc market.

Galfan, a new and improved galvanizing alloy developed by the International Lead Zinc Research Organization Inc. (ILZRO), was first used commercially in 1983 in Japan. The alloy contains about 95 per cent zinc, 5 per cent aluminum and a small but significant amount of rare earth metals. The new alloy outperforms conventional galvanizing and Galvalume in corrosion resistance and several other characteristics. Another advantage is that only minor modifications are necessary to adapt existing galvanizing lines compared with the major cost of converting a line for Galvalume. Galvalume, (55 per cent aluminum, 43.4 per cent zinc and 1.6 per cent silicon) developed by Bethlehem Steel Corporation, was introduced to the U.S. market in 1976 and is being used in specialized applications. These alloys are complementary to galvanizing and increase the potential market for zinc.

New gravity casting and die casting alloys being developed and promoted have the potential to add considerably to total zinc demand during the next ten years.

OUTLOOK

Overcapacity and overproduction continue to plague the industry. As it becomes more disciplined, the market may return to a close balance between supply and demand and prices will return closer to historical levels. The current slow recovery in world economic activity will lengthen the period that will be required to work off overcapacity in all sectors of the industry. It is estimated that this will require at least five years. In the meantime, any perception in the market place of oversupply will continue to put downward pressure on prices.

Zinc consumption in the western world is projected to grow at 1.5 per cent per annum to the end of the century, which is much lower than historical growth rates. Factors underlying this relatively low forecast growth are the maturing of zinc markets in industrialized countries and the expected slowing in world economic growth.

Mine production in Canada in 1987 is expected to increase marginally from that of 1986 but metal production is expected to increase some 14 to 15 per cent with the settlement of the strike at Canadian Electrolytic Zinc Limited. However, pressures will continue on industry to reduce costs and maintain a low level of inventories.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(% unless otherwise specified)		
CANADA					
32900-1	Zinc in ores and concentrates	free	free	free	free
34500-1	Zinc dross and zinc scrap for remelting, or for processing into zinc dust	free	free	10	free
34505-1	Zinc spelter, zinc and zinc alloys containing not more than 10 per cent by weight of other metal or metals, in the form of pigs, slabs, blocks, dust or granules	free	free	2¢/lb	free
35800-1	Zinc anodes	free	free	10	free

UNITED STATES (MFN)

626.04	Zinc, unwrought, alloyed	19.0	
		1986	1987
602.20	Zinc in ores and concentrates	35¢/lb	30¢/lb
626.02	Zinc, unwrought, unalloyed	1.6	1.5
626.10	Zinc, waste and scrap (duty temporarily suspended)	2.5	2.1

EUROPEAN ECONOMIC COMMUNITY (MFN)

		1986	Base Rate	Concession Rate
26.01	Zinc, ores and concentrates	free	free	free
79.01	Zinc, unwrought	3.5	3.5	3.5
	Zinc, waste and scrap	free	free	free

JAPAN (MFN)

		1986	Base Rate	Concession Rate
26.01	Zinc, ores and concentrates	free	free	free
79.01	Zinc, unwrought, unalloyed	2.2	2.5	2.1
	Zinc, unwrought, alloyed	7.2 yen/kg	10 yen/kg	7 yen/kg
	Zinc, waste and scrap	1.9	2.5	1.9

Sources: The Customs Tariff, 1986, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated 1986, USITC Publication 1775; U.S. Federal Register Vol. 44, No. 241; Official Journal of the European Communities, Vol. 28, No. L 331, 1986; Customs Tariff Schedules of Japan, 1986.

TABLE 1. CANADA, ZINC PRODUCTION AND TRADE, 1984-86 AND CONSUMPTION 1984 AND 1985

	1984		1985		1986P	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Production						
All forms[1]						
Ontario	303 425	426,920	280 475	351,716	303 549	375,187
New Brunswick	232 792	327,539	197 503	247,669	166 107	205,308
Northwest Territories	274 920	386,813	284 223	356,415	283 557	350,476
British Columbia	95 508	134,379	108 072	135,552	137 687	170,181
Manitoba	48 854	68,737	64 689	81,120	57 742	71,369
Quebec	58 249	81,968	75 812	95,068	42 000	51,912
Newfoundland	42 620	59,967	32 730	41,043	6 686	8,264
Saskatchewan	6 160	8,666	5 663	7,101	3 213	3,972
Yukon	173	244	108	136	54 562	67,439
Total	1 062 701	1,495,233	1 049 275	1,315,791	1 055 103	1,304,108
Mine output[2]	1 207 098		1 172 238		1 290 000	
Refined[3]	683 156		692 406		570 596	
Exports					(Jan.-Sept.)	
Zinc blocks, pigs and slabs						
United States	331 118	443,520	371 156	438,913	266 536	299,390
People's Republic of China	44 785	47,738	44 059	44,960	2 042	1,937
United Kingdom	39 464	47,127	41 089	44,191	22 605	21,108
Taiwan	12 918	14,680	10 776	11,735	11 629	10,419
West Germany	9 125	10,735	4 509	5,269	749	669
New Zealand	8 860	10,208	5 761	5,714	4 682	3,805
Philippines	5 388	5,904	3 307	3,551	3 305	2,839
Thailand	7 708	9,457	2 953	3,386	-	-
India	7 681	9,192	11 836	13,221	3 741	3,106
Hong Kong	7 588	9,319	5 636	6,782	4 767	4,451
Indonesia	5 701	6,818	5 578	6,212	2 991	2,677
Italy	7 203	7,334	4 124	4,281	2 078	1,752
Japan	5 692	6,253	7 211	8,158	4 174	3,881
Singapore	4 661	5,105	852	974	1 291	1,133
Other countries	31 841	35,030	36 774	38,110	13 264	11,354
Total	529 653	668,420	555 621	635,457	343 934	328,559
Zinc contained in ores and concentrates						
Belgium-Luxembourg	314 017	154,469	202 834	106,889	99 931	48,566
Japan	63 288	34,968	28 060	15,749	25 413	14,742
Netherlands	39 400	11,073	2 826	1,190	-	-
West Germany	30 909	12,868	44 493	22,654	14 013	4,195
United States	28 371	20,148	41 909	28,384	11 039	5,955
France	29 800	19,115	29 138	16,369	29 217	13,802
United Kingdom	16 816	9,217	20 165	9,368	23 913	11,089
Italy	8 060	4,577	21 340	10,461	24 528	10,549
Algeria	3 528	2,587	3 322	2,348	-	-
Spain	3 495	2,906	-	-	-	-
Bulgaria	3 305	2,490	-	-	2 242	1,677
Other countries	9 144	5,372	15 657	8,342	37 269	18,961
Total	550 213	279,785	409 744	217,754	267 565	129,536
Zinc alloy scrap, dross and ash[4]						
United States	8 697	6,689	7 025	4,967	5 486	3,489
West Germany	7 026	3,133	7 477	3,462	4 531	1,896
United Kingdom	1 322	503	576	366	663	1,079
Italy	-	563	128	94	37	28
Belgium-Luxembourg	622	269	274	172	54	106
Japan	373	157	353	190	52	20
Other countries	1 185	944	2 246	1,483	6 284	3,482
Total	19 463	12,258	18 079	10,634	17 107	10,100
Zinc dust and granules						
United States	3 288	5,115	5 581	7,413	2 976	4,470
Venezuela	62	119	114	204	-	-
West Germany	92	47	93	62	-	-
United Kingdom	16	8	19	31	-	-
Other countries	104	127	2 261	1,894	94	185
Total	3 533	5,416	8 068	9,604	3 074	4,655

TABLE 1. (cont'd.)

	1984		1985		1986P	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Zinc fabricated material, nes						
United States	992	3,079	1 234	3,672	786	3,239
United Kingdom	19	73	17	85	-	-
Other countries	136	546	28	51	74	79
Total	1 147	3,698	1 279	3,808	860	3,318
					(Jan.-Sept.)	
Imports						
In ores, concentrates and scrap	40 456	25,139	17 586	9,965	30 404	13,246
Dust and granules	844	1,485	987	1,670	555	880
Slabs, blocks, pigs and anodes	6 756	8,850	1 814	2,127	5 022	5,839
Bars, rods, plates, strip and sheet	387	1,057	688	1,277	352	868
Slugs, discs and shells	20	18	-	-	14	9
Zinc oxide	1 350	1,479	1 104	1,565	1 181	982
Zinc sulphate	2 294	1,199	1 590	951	1 508	852
Zinc fabricated materials, nes	674	2,147	523	1,843	675	2,252
Total	52 786	41,374	24 288	19,407	39 711	24,938

	1984			1985P		
	Primary	Secondary	Total	Primary	Secondary	Total
	(tonnes)					
Consumption[5]						
Zinc used for, or in the manufacture of:						
Copper alloys (brass, bronze, etc.)	13 118)			7 348		
Galvanizing: electro	1 869)	1 094	78 851	2 980	1 279	77 513
hot dip	62 770)			65 904		
Zinc die-cast alloy	14 643	X	X	14 152	X	X
Other products (including rolled and ribbon zinc, zinc oxide)	24 072	X	X	27 015	X	X
Total	116 472	3 101	150 528	117 399	5 855	123 254
Consumer stocks, year-end	12 405	220	12 625	11 210	697	11 907

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] New refined zinc produced from domestic primary materials (concentrates, slags, residues etc.) plus estimated recoverable zinc in ores and concentrates shipped for export. [2] Zinc content of ores and concentrates produced. [3] Refined zinc produced from domestic and imported ores. [4] Gross weight. [5] Consumer survey does not represent 100 per cent of Canadian consumption and is therefore consistently less than apparent consumption.
P Preliminary; - Nil; nes Not elsewhere specified; X Confidential.

TABLE 2. CANADA, ZINC MINE OUTPUT, 1984-86

	1984	1985	Jan.-Sept. 1986P
		(tonnes)	
Maritimes Total	305 653	273 826	177 733
Quebec	58 199	72 079	39 961
Ontario	337 799	297 337	236 626
Manitoba-Saskatchewan	60 927	74 270	44 938
British Columbia	107 150	114 257	101 461
Northwest Territories	337 370	340 469	330 712
Total	1 207 098	1 172 238	931 431

P Preliminary.

TABLE 3. CANADA, ZINC PRODUCTION, EXPORTS AND DOMESTIC SHIPMENTS, 1970, 1975, 1980-86

	Production		Exports		
	All Forms[1]	Refined[2]	In Ores and Concentrates	Refined	Total
			(tonnes)		
1970	1 135 714	417 906	809 248	318 834	1 128 082
1975	1 055 151	426 902	705 088	247 474	952 562
1980	883 697	591 565	434 178	471 949	906 127
1981	911 178	618 650	516 210	453 526	969 736
1982	965 607	511 870	457 751	470 390	928 141
1983	987 713	617 033	626 178	500 448	1 126 626
1984	1 062 701	683 156	539 633	529 659	1 069 292
1985	1 049 275	692 406	409 744	555 621	964 365
1986P	1 055 103	570 076	..	..	..

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] New refined zinc produced from domestic primary materials (concentrates, slags, residues, etc.) plus estimated recoverable zinc in ores and concentrates shipped for export. [2] Refined zinc produced from domestic and imported ores.
P Preliminary; .. Not available.

TABLE 4. WESTERN WORLD, PRIMARY ZINC STATISTICS, 1983-86

	1983	1984	1985	1986e
		(000 tonnes)		
Mine Production (Zinc Content)	4 811	5 071	5 114	5 155
Metal Production	4 643	4 877	4 968	4 870
Metal Consumption	4 577	4 718	4 713	4 880

Source: International Lead and Zinc Study Group.
e Estimated by Energy, Mines and Resources Canada.

TABLE 5. CANADA, ZINC-BEARING DEPOSITS CONSIDERED MOST PROMISING FOR FUTURE PRODUCTION

Company and Province	Deposit Name	Indicated Tonnage	Per Cent Zinc	Zinc Content
		(000 tonnes)		(000 tonnes)
New Brunswick				
Billiton Canada Ltd. and Calgroup Graphics Corporation Ltd.	Restigouche	2 900	6.55	190.0
Caribou-Chaleur Bay Mines Ltd.	Caribou	37 000	4.48	1 657.6
Cominco Ltd.	Stratmat 61	2 050	6.29	128.9
Key Anacon Mines Limited	Middle Landing	1 690	7.43	125.6
Falconbridge Limited and Bay Copper Mines Limited	Halfmile Lake	12 350	7.50	763.0
		55 990	5.12	2 865.1
Quebec				
Noranda Inc.	Magusi	3 730	3.55	132.4
Noranda Inc.	La Gauchetière	1 600	4.50	72.0
		5 330	3.83	204.4
Ontario				
Corporation Falconbridge Copper	Winston Lake	3 415	16.0	546.4
British Columbia				
Curragh Resources Corporation Regional Resources Ltd./ Canamax Resources Inc./	Cirque	21 700	9.00	1 953.0
Procan Exploration Company Limited	Midway	6 078	12.14	737.9
Esso Minerals Canada	Kutcho Creek	15 700	2.16	339.1
		43 478	6.97	3 030.0
Yukon Territory				
Curragh Resources Corporation	DY zone	21 000	6.90	1 449.0
	Swim Lake	4 540	5.50	249.7
Hudson Bay Mining and Smelting Co., Limited	Tom	8 000	8.40	672.0
Aberford Resources Ltd. and Ogilvie Joint Venture	Jason	11 790	6.57	774.6
Placer Development Limited and USX Corporation	Howard's Pass	120 000	5.40	6 480.0
Novamin Resources Inc. and Barytex Resources Corp.	MEL	4 780	5.10	243.8
		170 110	5.80	9 869.1
Northwest Territories				
Cominco Ltd. and Etruscan Enterprises Ltd.	Seven deposits	19 050	4.98	948.7
Cadillac Explorations Limited	Prairie Creek	1 452	12.17	176.7
Falconbridge Limited	Izok Lake	11 020	13.77	1 517.5
Westmin Resources Limited, Du Pont Canada Inc. and Philipp Brothers (Canada) Ltd.	Seven deposits	7 260	7.0[e]	508.2
		38 782	8.13	3 151.1
Canada		317 105	6.20	19 666.1

Source: "MR 209 Mine Reserves, January 1985 and Currently Promising Deposits, Gold, Silver, Lead, Zinc, Copper, Molybdenum": Energy, Mines and Resources Canada 1985.
[e] Estimated.

TABLE 6. WESTERN WORLD ZINC INDUSTRY, PRODUCTION AND CONSUMPTION, 1985

	Mine Production	Metal Production	Metal Consumption
	(000 tonnes)		
Europe			
Austria	22	25	32
Belgium	-	271	169
Denmark[1]	70	-	12
Finland	60	161	26
France	41	247	247
Germany F.R.	118	367	409
Greece	21	-	15
Ireland	192	-	1
Italy	45	210	218
Netherlands	-	203	51
Norway	26	93	17
Portugal	-	6	8
Spain	234	216	103
Switzerland	-	-	26
Sweden	212	-	35
United Kingdom	5	74	194
Yugoslavia	66	87	90
Total	1 112	1 960	1 653
Africa			
Algeria	13	35	9
East Africa	-	-	14
Egypt	-	-	18
Morocco	15	-	5
Nigeria	-	-	-
South Africa[2]	128	94	84
Tunisia	5	-	1
West Africa	-	-	21
Zaire	68	66	1
Zambia	51	23	1
Others	-	-	1
Total	280	218	155
Americas			
Argentina	37	31	29
Bolivia	38	-	-
Brazil	85	116	141
Canada	1 172	692	143
Chile	22	-	-
Colombia	2	-	19
Honduras	44	-	-
Mexico	291	182	101
Peru	583	163	41
United States	252	312	941
Venezuela	-	-	16
Others	-	-	29
Total	2 526	1 496	1 460
Asia			
Hong Kong	-	-	22
India	53	71	130
Indonesia	-	-	51
Iran	50	-	17
Israel	-	-	10
Japan	253	740	780
Korea, Rep.	42	109	120
Malaysia	-	-	19
Philippines	2	-	13
Taiwan	-	-	49
Thailand	68	59	42
Turkey	37	22	46
Others	5	-	39
Total	510	1 001	1 338
Oceania			
Australia	686	293	86
New Zealand	-	-	21
Total	686	293	107
Total non-socialist world	5 114	4 968	4 713

Source: International Lead and Zinc Study Group.
[1] Includes Greenland. [2] Includes Namibia.
- Nil.

TABLE 7. CANADA, PRIMARY ZINC METAL CAPACITY, 1986

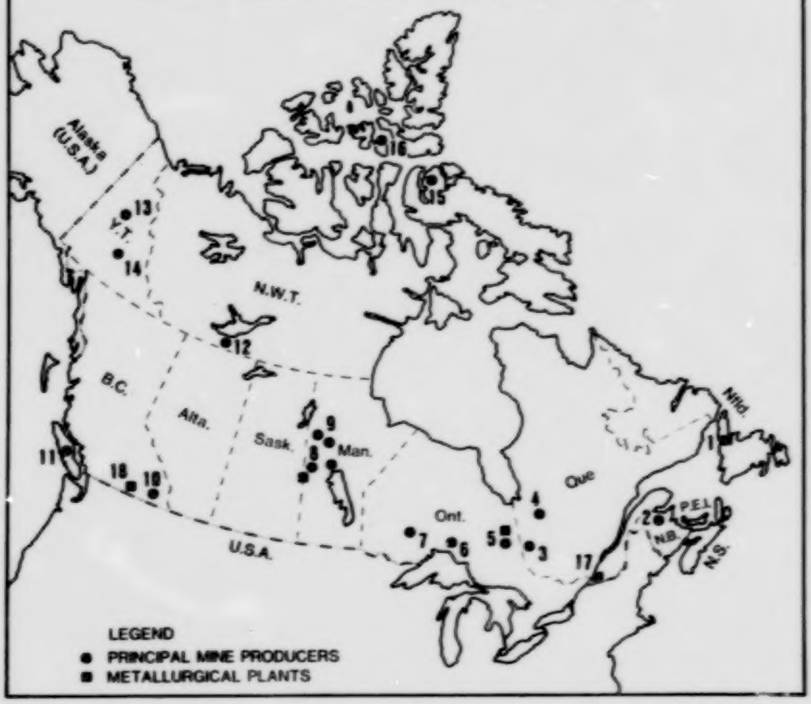
Company and Location	Annual Rated Capacity
	(tonnes of slab zinc)
Canadian Electrolytic Zinc Limited (CEZ) Valleyfield, Quebec	227 000
Falconbridge Limited Timmins, Ontario	133 000
Hudson Bay Mining and Smelting Co., Limited Flin Flon, Manitoba	73 000
Cominco Ltd. Trail, British Columbia	272 000
Canada total	705 000

TABLE 8. MONTHLY AVERAGE ZINC PRICES (High Grade Zinc)

	European Producer Price ($US/tonne)	American Producer (U.S.¢/lb)	Canadian Producer (Cdn.¢/lb)	LME Settlement (£/tonne)
1985				
January	900.00	42.9	58.2	769.3
February	900.00	42.6	58.2	811.0
March	922.62	43.2	61.8	818.4
April	958.33	44.9	64.0	752.4
May	952.17	45.1	64.0	706.0
June	907.50	43.7	62.5	630.9
July	847.39	41.4	57.0	555.4
August	830.00	39.8	55.5	531.1
September	815.71	38.0	54.6	505.4
October	753.91	35.9	52.0	444.5
November	672.86	33.3	48.0	415.0
December	682.82	33.6	48.0	474.3
Year Average	845.28	40.4	57.0	617.8
1986				
January	700.00	32.9	44.8	452.1
February	680.50	30.9	42.1	425.8
March	670.00	31.2	45.0	426.4
April	698.64	32.1	46.1	440.5
May	738.18	33.0	48.3	465.0
June	817.14	36.5	54.9	533.1
July	840.00	39.5	60.4	535.6
August	845.71	40.8	60.5	549.4
September	901.82	43.6	63.5	592.6
October	920.00	46.0	67.0	621.3
November	910.00	45.9	67.5	575.9
December	870.00	43.5	60.5	554.6
Year Average	799.33	38.0	55.1	514.4

Sources: Metals Week, ILZSG, Northern Miner.

ZINC PRODUCERS IN CANADA, 1986


Alaska (U.S.A.)
Y.T.
N.W.T.
B.C.
Alta.
Sask.
Man.
Ont.
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18
LEGEND
● PRINCIPAL MINE PRODUCERS
■ METALLURGICAL PLANTS

Principal Producers
(numbers refer to numbers on map above)

1. Newfoundland Zinc Mines Limited
2. Brunswick Mining and Smelting Corporation Limited
3. Corporation Falconbridge Copper Lake Dufault Division
Noranda Inc. and Les Mines Gallen Limitée (Gallen mine)
4. Noranda Inc. (Matagami Division)
5. Falconbridge Limited
6. Noranda Inc. (Geco Division)
7. Mattabi Mines Limited
Noranda Inc. (Lyon Lake)
8. Hudson Bay Mining and Smelting Co., Limited (Chisel Lake, Osborne Lake, Stall Lake, Ghost Lake, Anderson Lake, Westarm, Flin Flon, White Lake, Centennial, Trout Lake, Spruce Point)
9. Sherritt Gordon Mines Limited (Ruttan mine)
10. Cominco Ltd. (Sullivan mine)
Teck Corporation (Beaverdell mine)
Dickenson Mines Limited (Silmonac mine)
11. Westmin Resources Limited
12. Pine Point Mines Limited
13. United Keno Hill Mines Limited
14. Curragh Resources Corporation
15. Nanisivik Mines Ltd.
16. Cominco Ltd. (Polaris mine)

Metallurgical Plants

5. Falconbridge Limited, Timmins
8. Hudson Bay Mining and Smelting Co., Limited, Flin Flon
17. Canadian Electrolytic Zinc Limited, Valleyfield
18. Cominco Ltd., Trail

Principal Canadian Nonferrous and Precious Metal Mine Production in 1985, with Highlights for 1986

PRINCIPAL CANADIAN NONFERROUS AND PRECIOUS METAL MINE PRODUCTION IN 1985, WITH HIGHLIGHTS FOR 1986

Company and Mine/Mill Location	Capacity	Grades of Ore Milled						Ore Milled	Metal Contained in All Concentrates Produced						1986 Highlights
		Cu	Ni	Pb	Zn	Ag	Au		Copper	Nickel	Zinc	Lead	Silver	Gold	
	(tonnes per day)	%	%	%	%	(g/tonne)		(tonnes)			(tonnes)		(kilograms)		
NEWFOUNDLAND															
Newfoundland Zinc Mines Limited Daniel's Harbour	1 500	-	-	-	7.90	-	-	47 390	-	-	36 506	-	-	-	Production suspended April 1986.
NEW BRUNSWICK															
Brunswick Mining and Smelting Corporation Limited, No. 12 mine Bathurst	10 000	0.32	-	3.47	8.64	98.1	-	3 311 608	8 061	-	247 806	87 606	233 256	-	No. 3 shaft to be deepened.
QUEBEC															
Agnico-Eagle Mines Limited Joutel	1 630	-	-	-	-	0.9	6.55	399 038	-	-	-	-	337	2 351	
Aiguebelle Resources Inc. Rouyn	1 000	-	-	-	-	1.4	3.59	309 220	-	-	-	-	583	1 551	
American Barrick Resources Corporation Camflo Division Val-d'Or	1 180	-	-	-	-	0.3	3.96	428 737	-	-	-	-	101	1 596	
Bachelor Lake Gold Mines Inc. Desmaraisville	450	-	-	-	-	0.5	4.05	148 852	-	-	-	-	60	596	
Belmoral Mines Ltd. Val-d'Or	820	-	-	-	-	0.9	8.26	208 607	-	-	-	-	170	1 623	

BP Resources Canada Limited (Selco Division) Joutel	1 500	3.28	-	-	0.60	37.3	1.30	577 116	18 133	-	3 255	-	19 117	657	New A-1 zone brought into production late-1986.
Campbell Resources Inc. Chibougamau	3 180	1.25	-	-	-	7.4	3.29	287 127	3 479	-	-	-	1 350	839	
Corporation Falconbridge Copper															
Lake Dufault Division Millenbach and Corbet mines Noranda	1 540	2.96	-	-	2.50	25.7	1.03	474 390	13 485	-	10 875	-	7 979	386	Lake Dufault mine closed September 1986.
Lake Shortt Division Desmaraisville	1 150	-	-	-	-	0.2	5.56	315 564	-	-	-	-	63	1 596	
Opemiska Division Perry, Springer & Cooke mines, Chapais	2 720	1.15	-	-	-	8.9	2.81	608 421	6 793	-	-	-	4 361	1 542	
Kiena Gold Mines Limited Val-d'Or	1 250	-	-	-	-	1.0	5.90	370 767	-	-	-	-	359	2 083	
Lac Minerals Ltd. Doyon Division Cadillac	1 360	-	-	-	-	0.5	5.11	500 766	-	-	-	-	244	2 411	
Est-Malartic Division Malartic	1 720	-	-	-	-	0.3	4.71	625 641	-	-	-	-	203	2 789	
Terraine Aurifère Division Cadillac	1 810	-	-	-	-	1.6	5.38	582 069	-	-	-	-	848	2 906	
Muscocho Explorations Limited Montauban mine Montauban	370	-	-	-	-	11.9	5.22	135 029	-	-	-	-	722	620	
Noranda Inc.															
Gaspé Division Copper Mountain and Needle Mountain mines Murdochville	3 720	1.22	-	-	-	5.9	0.07	1 065 328	-	-	-	-	6 712	18	E-32 orebody commenced operation, late-1986.
Les Mines Gallen Limitée (Chadbourne circuit)	3 450	-	-	-	5.90	27.1	1.03	453 010	-	-	23 013	-	5 037	433	Production suspended early-1986.
Mattagami Division Matagami	3 950	1.06	-	-	4.11	19.1	0.41	1 095 757	9 625	-	39 211	-	10 865	164	
Northgate Mines Inc. Copper Rand and Portage mines Chibougamau	2 940	1.70	-	-	-	9.7	4.46	624 376	10 328	-	-	-	4 081	2 462	

Principal Canadian Nonferrous and Precious Metal Mine Production in 1985, with Highlights for 1986 (cont'd)

Company and Mine/Mill Location	Capacity	Grades of Ore Milled						Ore Milled	Metal Contained in All Concentrates Produced						1986 Highlights
		Cu	Ni	Pb	Zn	Ag	Au		Copper	Nickel	Zinc	Lead	Silver	Gold	
	(tonnes per day)	%	%	%	%	(g/tonne)		(tonnes)			(tonnes)		(kilograms)		
QUEBEC (cont'd)															
Sigma Mines (Quebec) Limited Val-d'Or	1 270	-	-	-	-	0.8	4.42	434 956	-	-	-	-	316	1 850	
Société québécoise d'exploration minière (SOQUEM)	540	-	-	-	-	0.5	6.41	63 176	-	-	-	-	30	382	Sold to Cambior Inc. in 1986.
Teck Corporation Lamaque Division (including custom milled ore) Val-d'Or	1 900	-	-	-	-	1.0	8.57	79 102	-	-	-	-	74	646	Mine closed early-1985.
ONTARIO															
Agnico-Eagle Mines Limited Silver Division Cobalt	360	-	-	-	-	963.1	-	53 630	-	-	-	-	48 483	-	
Campbell Red Lake Mines Limited Red Lake	980	-	-	-	-	2.2	20.85	355 615	-	-	-	-	740	7 034	
Detour Joint Venture James Bay	2 500	-	-	-	-	0.9	3.36	813 039	-	-	-	-	644	2 543	
Dickenson-Sullivan Joint Venture Red Lake	730	-	-	-	-	1.4	11.31	195 172	-	-	-	-	226	1 950	
Dome Mines, Limited South Porcupine	2 722	-	-	-	-	0.7	4.39	932 677	-	-	-	-	601	3 913	
Falconbridge Limited Sudbury operations	10 340	1.02	1.24	-	-	6.9	0.14	2 879 279	27 952	30 070	-	-	9 872	197	
Timmins operations	12 250	2.96	-	0.23	6.10	81.7	-	4 532 592	129 845	-	246 601	8 874	308 996	-	Formerly Kidd Creek Mines Ltd., acquired in 1986. Zinc smelter expansion completed. Copper refinery expansion near completion in 1986.

Inco Limited (10 mines, Sudbury area)	49 440	1.23	1.32	-	-	5.1	0.17	11 026 658	125 791	119 668	-	-	44 232	1 152	Closed from June 2 to August 10, 1986. Shebandowan mine placed on standby in 1986.
Kerr Addison Mines Limited Virginiatown	1 225	-	-	-	-	0.2	4.42	340 074	-	-	-	-	74	1 468	
Lac Minerals Ltd.															
Hemlo Division Marathon	3 300	-	-	-	-	0.1	2.50	135 171	-	-	-	-	19	322	Mine started up December 1985.
Macassa Division Kirkland Lake	450	-	-	-	-	1.8	14.47	157 553	-	-	-	-	266	2 191	
Lake Asbestos of Quebec. Ltd. Aquarius Mill	270	-	-	-	-	0.9	14.06	67 157	-	-	-	-	55	906	
Mattabi Mines Limited Mattabi and Lyon Lake mines Ignace	2 720	1.00	-	0.82	8.23	116.9	0.38	606 653	5 628	-	46 536	4 073	61 738	164	
Noranda Inc.															
Geco Division Manitouwadge	3 860	1.69	-	0.15	2.99	45.0	0.14	1 304 615	21 092	-	35 215	1 294	45 857	89	
Golden Sceptre - Goliath Joint Venture Marathon	3 000	-	-	-	-	0.3	11.01	324 853	-	-	-	-	77	3 040	Poured first gold early April 1985.
Pamour Inc.															
Pamour Division Timmins	2 720	-	-	-	-	0.8	2.54	877 003	-	-	-	-	368	1 937	
Schumacher Division Schumacher	2 720	0.01	-	-	-	3.6	3.29	675 861	97	-	-	-	1 216	1 854	
Schumacher Go Mill Schumacher	250	-	-	-	-	-	4.39	9 097	-	-	-	-	-	29	
Queenston-Inco Exploration Joint Venture Kirkland Lake	590	-	-	-	-	0.2	3.34	209 817	-	-	-	-	46	604	Operation shut down mid-1986.
Royex Gold Mining Corporation - American Barrick Resources Corporation Renabie Mine Wawa	450	-	-	-	-	1.8	7.06	140 445	-	-	-	-	227	926	
Teck Corporation - International Corona Resources Ltd. Joint Venture Marathon	1 000	-	-	-	-	0.4	6.51	153 383	-	-	-	-	56	965	

Principal Canadian Nonferrous and Precious Metal Mine Production in 1985, with Highlights for 1986 (cont'd)

Company and Mine/Mill Location		Grades of Ore Milled						Ore	Metal Contained in All Concentrates Produced						
	Capacity	Cu	Ni	Pb	Zn	Ag	Au	Milled	Copper	Nickel	Zinc	Lead	Silver	Gold	**1986 Highlights**
	(tonnes per day)	%	%	%	%	(g/tonne)		(tonnes)			(tonnes)		(kilograms)		
MANITOBA															
Hudson Bay Mining and Smelting Co., Limited (9 mines), Flin Flon & Snow Lake concentrators	10 520	2.38	-	0.12	2.90	18.5	1.57	1 926 348	43 092	-	45 151	1 590	26 238	1 791	
Inco Limited Thompson underground and open pit mines Thompson district	12 700	0.24	2.49	-	-	5.14	0.10	1 888 216	4 222	42 650	-	-	7 575	118	The Thompson open pit was officially opened on September 23, 1986.
Sherritt Gordon Mines Limited															
Fox mine Lynn Lake district	2 720	1.85	-	-	2.01	15.4	0.65	721 018	12 565	-	12 815	-	6 314	249	Mine closed October 1985.
Ruttan mine Leaf Rapids	9 070	1.38	-	-	1.40	10.2	0.38	1 621 520	20 867	-	19 438	-	9 461	321	Deepening program completed. Company wrote off value of operations at end of 1986.
BRITISH COLUMBIA															
Brenda Mines Ltd. Peachland	27 220	0.18	-	-	-	1.6	0.02	3 006 313	4 693	-	-	-	2 495	34	Also produces molybdenum.
Broken Hill Proprietary Company Limited, The Utah Division Island Copper mine Port Hardy	37 200	0.39	-	-	-	1.6	0.21	16 506 367	54 941	-	-	-	13 228	1 718	Also produces molybdenum and rhenium.
Cominco Ltd. Copper Division Valley Copper mine Logan Lake	22 680	0.49	-	-	-	3.09	0.03	9 333 730	39 528	-	-	-	14 450	126	Became part of Highland Valley Copper Corporation, July 1986.
Sullivan mine Kimberley	9 070	-	-	5.14	4.12	51.4	-	2 174 577	-	-	83 626	103 335	99 086	-	Mine closed for 6 weeks summer 1986.
Dickenson Mines Limited Silvana Division Silmonac mine New Denver	110	-	-	9.44	6.55	651.1	-	23 059	-	-	1 447	2 099	14 603	-	

Equity Silver Mines Limited Houston	5 300	0.58	-	-	-	115.9	0.99	2 058 700	8 787	-	-	-	142 226	976	Mill expanded to 10 000 tpd, June 1986.
Gibraltar Mines Limited McLeese Lake	37 200	0.33	-	-	-	1.0	0.01	13 400 933	36 599	-	-	-	6 870	48	4 535 tpd SXEW plant started up October 1986.
Lornex Mining Corporation Ltd. Lornex mine Logan Lake	72 580	0.39	-	-	-	1.9	-	29 214 991	98 873	-	-	-	26 816	-	Became part of Highland Valley Copper Corporation, July 1986.
Mosquito Creek Gold Mining Company Limited, The Barker-Wells area	91	-	-	-	-	4.3	9.57	7 904	-	-	-	-	29	64	
Newmont Mines Limited Similkameen Division Princeton	19 960	0.42	-	-	-	2.4	0.16	6 884 343	23 900	-	-	-	8 293	540	
Noranda Inc. Bell Copper mine Babine Lake	15 420	0.44	-	-	-	1.3	0.22	1 587 742	5 362	-	-	-	1 005	175	Mine life extended to end of 1989.
Taurus Resources Ltd. Cassiar area	180	-	-	-	-	3.5	6.72	38 450	-	-	-	-	6	11	
Teck Corporation Afton Operating Corporation Kamloops	6 800	0.98	-	-	-	5.2	0.75	2 651 281	22 367	-	-	-	9 597	1 510	Main pit to be mined out in early-1987.
Beaverdell mine Beaverdell	100	-	-	0.26	0.42	294.9	-	36 820	-	-	127	79	9 386	-	
Total Erickson Resources Ltd. Cassiar	180	-	-	-	-	9.6	10.63	58 016	-	-	-	-	468	567	Mill rebuilt after fire in early-1986 expanded capacity to 300 tpd.
Westmin Resources Limited H-W, Lynx, Myra mines Buttle Lake	2 720	1.64	-	0.55	6.18	59.3	2.06	585 669	8 880	-	31 710	2 869	27 154	813	New H-W mine and mill commenced operation in 1985 - mill rate, 3 000 tpd by third quarter, 1986. Myra mined out October 1985.
YUKON TERRITORY															
United Keno Hill Mines Limited Elsa, Husky, No Cash, Keno mines Elsa	450	-	-	2.36	0.25	716.93	-	67 684	-	-	63	960	40 290	-	

Principal Canadian Nonferrous and Precious Metal Mine Production in 1985, with Highlights for 1986 (cont'd)

Company and Mine/Mill Location	Capacity	Grades of Ore Milled						Ore Milled	Metal Contained in All Concentrates Produced						1986 Highlights
		Cu	Ni	Pb	Zn	Ag	Au		Copper	Nickel	Zinc	Lead	Silver	Gold	
	(tonnes per day)	%	%	%	%	(g/tonne)		(tonnes)			(tonnes)		(kilograms)		
NORTHWEST TERRITORIES															
Cominco Ltd. Con and Rycon mines Yellowknife	640	-	-	-	-	5.4	11.54	203 487	-	-	-	-	614	2 429	
Polaris mine Little Cornwallis Island	2 650	-	-	3.50	13.00	-	-	935 998	-	-	110 869	31 567	-	-	6 week summer shutdown, 1986.
Echo Bay Mines Ltd. Lupin mine Contwoyto Lake	1 560	-	-	-	-	2.2	11.98	570 931	-	-	-	-	-	6 081	
Giant Yellowknife Mines Limited Yellowknife Division Giant mine Yellowknife	1 090	-	-	-	-	1.8	7.82	302 369	-	-	-	-	669	2 090	
Salmita Division	180	-	-	-	-	7.2	31.5	68 542	-	-	-	-	650	1 981	
Nanisivik Mines Ltd. Baffin Island	2 200	-	-	0.87	9.17	63.1	-	692 536	-	-	61 039	5 676	23 956	-	
Pine Point Mines Limited Pine Point mine Pine Point	9 980	-	-	1.00	8.20	-	-	2 137 297	-	-	165 511	61 616	-	-	Commenced accelerated production plan.
Terra Mines Ltd. Smallwood and Norex mines Camsell River	654	0.30	-	0.15	0.10	1 282.59	-	5 361	16	-	1	6	6 731	-	Closed April 1985.

Statistical Report

The statistical material contained in this summary was principally derived from surveys conducted by the Information Systems Division of the Mineral Policy Sector of Energy, Mines and Resources Canada.

The statistical survey program of Energy, Mines and Resources Canada is conducted jointly with the provincial governments and Statistics Canada. This joint program is intended to minimize the reporting burden on the mineral companies. The cooperation of the companies that provide information is greatly appreciated. Without this cooperation, a statistical report of this nature would not be possible. International mineral statistics contained in this summary are derived from the U.S. Bureau of Mines, the American Bureau of Metal Statistics, the World Bureau of Metal Statistics, **Metals Week**, and the **Engineering and Mining Journal**.

This statistical summary of the mineral industry in Canada for the year 1986 was prepared by J.T. Brennan and staff, Statistics Section, Mineral Policy Sector, Energy, Mines and Resources Canada, Ottawa. Telephone (613) 995-9466.

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CANADA, GENERAL ECONOMIC INDICATORS, 1971-85

		1971	1972	1973	1974	1975
Gross national product, current dollars	$ million	94,450	105,234	123,560	147,528	165,343
Gross national product, constant dollars (1971 = 100)	"	94,450	100,248	107,812	111,678	113,005
Value of manufacturing industry shipments	"	50,276	56,191	66,674	82,455	88,427
Value of mineral production	"	5,963	6,408	8,370	11,754	13,347
Merchandise exports	"	17,397	19,671	24,838	31,739	32,587
Merchandise imports	"	15,618	18,669	23,325	31,722	34,716
Balance of payments, current account	"	+431	-386	+108	-1,460	-4,757
Corporation profits before taxes	"	8,681	10,799	15,417	20,062	19,663
Capital investment, current dollars	"	20,800	23,051	27,848	34,260	40,044
Capital investment, constant dollars (1971 = 100)	"	20,800	21,955	24,384	25,694	26,661
Population	000's	21 568	21 802	22 043	22 364	22 697
Labour force	"	8 639	8 897	9 276	9 639	9 974
Employed	"	8 104	8 344	8 761	9 125	9 284
Unemployed	"	535	553	515	514	690
Unemployment rate	per cent	6.2	6.2	5.5	5.3	6.9
Labour income	$ million	51,528	57,570	66,501	79,846	93,299
Index industrial production	1971=100	100.0	107.6	119.0	122.8	115.5
Index manufacturing production	"	100.0	107.7	119.1	123.4	116.2
Index mining production	"	100.0	104.4	117.8	114.0	100.9
Index gross domestic product	"	100.0	105.2	114.1	119.3	120.4
Consumer price index	1981=100	42.2	44.2	47.6	52.8	58.5

P Preliminary; r Revised.

1976	1977	1978	1979	1980	1981	1982	1983^r	1984	1985^p
191,857	210,189	232,211	264,279	297,556	339,797	358,302	389,844	420,870	453,724
119,612	121,988	126,347	130,362	131,765	136,108	130,065	134,361	141,097	147,439
98,076	109,747	129,019	152,133	165,985	190,851	183,652	200,155	225,970	242,863
15,693	18,473	20,319	26,135	31,926	32,420	33,831	38,539	43,789	44,875
37,651	43,685	52,259	64,317	74,446	81,203	84,540	90,825	112,118	120,095
37,494	42,363	50,108	62,871	69,274	79,129	66,726	73,120	91,450	103,278
-4,109	-4,334	-4,917	-4,840	-1,114	-6,065	2,665	1,686	2,553	-2,648
19,985	21,090	25,360	34,884	36,456	32,638	21,110	32,684	39,606	41,762
44,927	48,376	52,482	60,921	69,196	82,058	79,330	76,448	78,489	86,909
27,731	27,606	27,585	29,448	30,461	32,401	29,265	27,609	27,804	28,970
22 993	23 258	23 476	23 671	23 936	24 342	24 634	24 886	25 124	25 359
10 203	10 500	10 895	11 231	11 573	11 904	11 958	12 183	12 399	12 639
9 477	9 651	9 987	10 395	10 708	11 006	10 644	10 734	11 000	11 311
726	849	908	836	865	898	1,314	1,448	1,399	1,328
7.1	8.1	8.3	7.4	7.5	7.5	11.0	11.9	11.3	10.5
109,053	120,508	131,702	148,256	167,936	194,074	207,594	218,963	232,220	248,544
122.6	125.7	129.9	137.9	135.9	136.5	123.0	129.2	140.5	146.7
123.1	125.5	131.9	138.1	133.7	137.8	121.3	128.1	138.6	145.0
103.1	106.1	97.8	107.1	109.6	104.6	92.7	96.6	110.4	112.2
126.4	130.1	134.4	139.3	139.8	145.5	139.2	142.9	150.0	156.4
62.9	67.9	73.9	80.7	88.9	100.0	110.8	117.2	122.3	127.2

TABLE 1. MINERAL PRODUCTION OF CANADA, 1984 AND 1985, AND AVERAGE 1981-85

	Unit of Measure	1984		1985P		Average 1981-85	
		(Quantity)	($000)	(Quantity)	($000)	(Quantity)	($000)
Metals							
Antimony	t	554	3,163	1 094	6,577	673	3,482
Bismuth	t	166	1,964	222	4,344	200	1,951
Cadmium	t	1 605	7,754	1 683	6,111	1 240	4,865
Cesium, pollucite, rubidium	t	..	(1)	..	(1)	89	210
Calcium	t	..	(1)	..	(1)	494	4,411
Cobalt	t	2 123	61,127	2 676	91,727	1 913	64,708
Columbium (Cb_2O_5)	t	2 767	18,778	3 300	(1)	2 728	18,691
Copper	000 t	722	1,365,695	730	1,445,357	682	1,380,060
Gold	kg	83 446	1,252,283	86 044	1,197,051	71 954	1,114,064
Ilmenite	t	..	(1)	..	(1)	330 030	9,719
Indium	kg	..	(1)	..	(1)	2 205	370
Iron ore	000 t	39 930	1,482,352	40 348	1,545,783	39 200	1,449,519
Iron remelt	000 t	..	134,827	..	(1)	499 977	120,073
Lead	000 t	264	195,292	264	152,304	268	193,806
Lithium, lepidolite, spodumene	t	..	(1)	..	(1)	68	328
Magnesium	t	..	(1)	..	(1)	7 297	27,814
Molybdenum	t	11 557	106,158	7 569	75,390	11 226	143,375
Nickel	000 t	174	1,166,140	176	1,234,961	145	1,004,329
Platinum group	kg	10 369	(1)	10 425	(1)	9 353	114,532
Rhenium	kg	..	(1)	..	(1)	532	639
Selenium	t	463	11,893	305	6,556	302	6,419
Silver	t	1 327	461,868	1 209	337,362	1 235	443,458
Strontium	t	..	(1)	..	(1)	72	1,831
Tantalum (Ta_2O_5)	t	-	-	39	3,045	41	6,690
Tellurium	t	19	511	20	543	21	648
Tin	t	209	3,761	113	1,795	167	2,650
Tungsten (WO_3)	t	4 196	(1)	4 002	(1)	2 974	45,147
Uranium (U)	t	10 272	901,573	10 029	957,660	8 455	831,717
Zinc	000 t	1 063	1,495,233	1 039	1,316,824	933	1,214,584
Total metals			8,670,372		8,546,740		8,210,091
Nonmetals							
Arsenious trioxide	t	..	(1)	..	(1)	2 269	960
Asbestos	000 t	837	379,275	744	352,275	879	407,209
Barite	000 t	64	6,974	70	6,335	56	5,393
Bentonite	000 t	..	(1)	..	(1)	49	2,760
Diatomite	t	..	(1)	..	(1)	2 658	185
Gemstone	t	184	1,118	190	1,151	147	690
Graphite	t	..	(1)	..	(1)	1 827	1,116
Gypsum	000 t	7 775	61,562	8 384	80,321	7 336	58,929
Magnesitic dolomite and brucite	000 t	112	8,145	139	10,491	83	9,230

Marl	000 t	..	(1)	..	(1)	10	135
Mica	000 t	..	(1)	..	(1)	11	3,176
Nepheline syenite	000 t	521	17,866	488	18,903	534	17,799
Peat	000 t	541	51,816	586	58,475	521	51,883
Potash (K_2O)	000 t	7 527	867,480	6 923	642,054	6 520	755,256
Pumice	t	..	(1)	..	(1)	538	13
Pyrite, pyrrhotite	000 t	-	-	-	-	3	66
Quartz	000 t	2 659	40,845	2 538	44,110	2 288	37,996
Salt	000 t	10 235	210,191	10 043	225,995	8 854	179,850
Serpentine	t	..	(1)	..	(1)	3 687	436
Soapstone, talc & pyrophyllite	000 t	123	11,154	132	13,683	121	8,472
Sodium antimonate	t	..	(1)	..	(1)	794	401
Sodium sulphate	000 t	389	37,702	354	33,387	456	40,118
Sulphur in smelter gas	000 t	844	63,200	773	65,902	741	52,169
Sulphur, elemental	000 t	8 353	609,141	8 250	881,655	7 639	627,147
Titanium dioxide	000 t	..	(1)	..	(1)	539	140,468
Total nonmetals			2,366,469		2,434,737		2,401,855
Fuels							
Coal	000 t	57 402	1,794,625	60 480	1,884,100	49 114	1,469,929
Natural gas	million m^3	78 266	7,940,883	80 181	7,905,997	76 095	7,321,427
Natural gas by-products	million m^3	19 640	2,849,820	19 674	2,747,919	18 935	2,535,852
Petroleum, crude	000 m^3	83 680	17,813,914	84 311	18,938,654	79 017	14,895,591
Total fuels			30,399,242		31,476,670		26,222,799
Structural materials							
Clay products	000 $	..	136,795	..	144,487	..	125,744
Cement	000 t	9 240	717,282	9 772	780,050	9 091	688,604
Lime	000 t	2 249	157,645	2 010	137,043	2 249	149,464
Sand and gravel	000 t	233 759	546,328	223 724	551,254	233 365	557,718
Stone	000 t	81 754	393,433	77 930	378,155	74 302	332,288
Total structural materials			1,951,483		1,990,989		1,853,819
Other minerals(1)			401,405		426,189		
Total, all minerals			43,788,971		44,875,325		38,688,565

Notes: (1) Other minerals include those commodities for which the value of production is confidential.
P Preliminary; .. Not available; - Nil.

TABLE 2. CANADA, VALUE OF MINERAL PRODUCTION, PER CAPITA VALUE OF MINERAL PRODUCTION, AND POPULATION, 1956-85

	Metallics	Industrial Minerals	Fuels	Other Minerals[1]	Total	Per Capita Value of Mineral Production	Population of Canada
		($ million)				($)	(000)
1956	1,146	420	519		2,085	129.65	16 081
1957	1,159	466	565		2,190	131.87	16 610
1958	1,130	460	511		2,101	122.99	17 080
1959	1,371	503	535		2,409	137.79	17 483
1960	1,407	520	566		2,493	139.48	17 870
1961	1,387	542	674		2,603	142.72	18 238
1962	1,496	574	811		2,881	155.05	18 583
1963	1,510	632	885		3,027	159.91	18 931
1964	1,702	690	973		3,365	174.45	19 291
1965	1,908	761	1,046		3,715	189.11	19 644
1966	1,985	844	1,152		3,981	198.88	20 015
1967	2,285	861	1,235		4,381	214.99	20 378
1968	2,493	886	1,343		4,722	228.10	20 701
1969	2,378	891	1,465		4,734	225.42	21 001
1970	3,073	931	1,718		5,722	268.68	21 297
1971	2,940	1,008	2,015		5,963	276.46	21 568
1972	2,956	1,085	2,367		6,408	293.92	21 802
1973	3,850	1,293	3,227		8,370	379.69	22 043
1974	4,821	1,731	5,202		11,754	525.55	22 364
1975	4,796	1,898	6,653		13,347	588.05	22 697
1976	5,315	2,269	8,109		15,693	682.51	22 993
1977	5,988	2,612	9,873		18,473	794.26	23 258
1978	5,682	2,986	11,578	73	20,319	865.51	23 476
1979	7,924	3,514	14,617	81	26,135	1,104.11	23 671
1980	9,666	4,201	17,944	115	31,926	1,333.79	23 936
1981	8,753	4,486	19,012	136	32,420	1,331.85	24 342
1982	6,874	3,709	23,038	215	33,837	1,373.59	24 634
1983[r]	7,398	3,741	27,154	245	38,539	1,548.62	24 886
1984	8,670	4,318	30,399	401	43,789	1,742.91	25 124
1985[P]	8,547	4,426	31,477	426	44,875	1,769.60	25 359

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[1] Other minerals include arsenious trioxide, bentonite, calcium, cesium, diatomite, graphite, ilmenite, indium, magnesium, mica, pumice, rhenium, rubidium, serpentine, strontium, titanium dioxide for which the value of production is confidential.
[P] Preliminary; [r] Revised.

TABLE 3. CANADA, VALUE OF MINERAL PRODUCTION BY PROVINCES, TERRITORIES AND MINERAL CLASSES, 1985P

	Metals		Industrial minerals		Fuels		Other minerals[1]		Total	
	($000)	(% of total)	($000)	(% of total)	($000)	(% of total)	($000)	(% of total)	($000)	(% of total)
Alberta	117	x	1,134,285	25.6	26,211,134	83.3	480	0.1	27,346,016	60.9
Ontario	3,275,947	38.3	1,024,045	23.1	89,592	0.3	176,071	41.3	4,565,649	10.2
Saskatchewan	456,925	5.3	719,949	16.3	2,603,406	8.3	2,320	0.5	3,782,600	8.4
British Columbia	1,070,332	12.5	337,424	7.6	1,997,699	6.3	1,016	0.2	3,406,471	7.6
Quebec	1,288,313	15.1	749,279	16.9	-	-	199,249	46.8	2,236,841	5.0
Newfoundland	873,275	10.2	53,835	1.2	-	-	-	-	927,110	2.1
Northwest Territories	577,754	6.8	38,105	0.9	194,474	0.6	33,478	7.9	843,811	1.9
Manitoba	537,133	6.3	100,908	2.3	181,350	0.6	9,068	2.1	828,459	1.8
New Brunswick	410,240	4.8	105,544	2.4	30,015	0.1	4,507	1.1	550,306	1.2
Nova Scotia	-	-	158,804	3.6	169,000	0.5	-	-	327,804	0.7
Yukon	56,710	0.7	1,313	x	-	-	-	-	58,023	0.1
Prince Edward Island	-	-	2,235	0.1	-	-	-	-	2,235	x
Total	8,546,740	100.0	4,425,726	100.0	31,476,670	100.0	426,189	100.0	44,875,325	100.0

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[1] Other minerals include arsenious trioxide, bentonite, calcium, cesium, diatomite, graphite, ilmenite, indium, magnesium, mica, pumice, rhenium, rubidium, serpentine, strontium, titanium dioxide for which the value of production is confidential.
P Preliminary; - Nil; x Amount too small to be expressed.

TABLE 4. CANADA, PERCENTAGE CONTRIBUTION OF LEADING MINERALS TO TOTAL VALUE OF MINERAL PRODUCTION, 1979-85

	1979	1980	1981	1982	1983	1984	1985P
Oil, crude	28.6	28.4	29.2	36.0	41.8	40.6	42.2
Natural gas	18.6	19.3	19.8	21.5	18.4	18.1	17.6
Natural gas by-product	5.5	5.7	6.5	6.8	7.0	6.5	6.1
Coal	3.3	2.9	3.3	3.8	3.4	4.1	4.2
Iron ore	6.9	5.3	5.4	3.6	3.3	3.4	3.4
Copper	5.8	5.8	4.7	3.5	3.5	3.1	3.2
Zinc	4.1	2.7	3.4	3.1	2.9	3.4	2.9
Nickel	3.2	4.7	3.8	1.8	2.0	2.7	2.8
Gold	2.3	3.7	2.8	2.9	3.2	2.9	2.7
Uranium (U)	2.4	2.2	2.5	2.5	1.7	2.1	2.1
Sulphur, elemental	0.6	1.4	2.0	1.7	1.1	1.4	2.0
Cement	2.5	1.8	2.1	2.0	1.6	1.6	1.7
Potash (K_2O)	2.8	3.2	3.1	1.9	1.7	2.0	1.4
Sand and gravel	1.8	1.6	1.6	1.6	1.6	1.2	1.2
Stone	1.3	1.1	1.0	0.8	0.8	0.9	0.8
Asbestos	2.3	1.9	1.7	1.1	1.0	0.9	0.8
Silver	1.8	2.6	1.4	1.2	1.4	1.1	0.8
Salt	0.4	0.4	0.4	0.5	0.4	0.5	0.5
Lead	1.6	0.9	0.8	0.6	0.4	0.4	0.3
Clay products	0.5	0.3	0.4	0.3	0.3	0.3	0.3
Lime	0.3	0.4	0.5	0.4	0.4	0.4	0.3
Other minerals	3.3	3.6	3.6	2.4	2.1	2.4	2.7
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

P Preliminary.

TABLE 5. PRODUCTION OF LEADING MINERALS BY PROVINCES AND TERRITORIES, 1985P

	Unit of measure	Nfld.	P.E.I.	Nova Scotia	New Brunswick	Quebec	Ontario
Petroleum, crude	000 m^3	-	-	-	x	-	109
	$000	-	-	-	15	-	23,878
Natural gas	million m^3	-	-	-	4	-	512
	$000	-	-	-	200	-	65,714
Natural gas by-products	000 m^3	-	-	-	-	-	-
	$000	-	-	-	-	-	-
Coal	000 t	-	-	2 830	555	-	-
	$000	-	-	169,000	29,800	-	-
Iron ore	000 t	21 269	-	-	-	14 800	4 192
	$000	835,633	-	-	-	..	..
Copper	000 t	-	-	-	7	69	280
	$000	-	-	-	13,031	136,265	554,169
Zinc	000 t	30	-	-	231	64	269
	$000	37,642	-	-	292,875	81,571	341,722
Nickel	000 t	-	-	-	-	-	138
	$000	-	-	-	-	-	968,358
Gold	kg	-	-	-	252	29 303	31 670
	$000	-	-	-	3,506	407,665	440,596
Uranium (U)	000 t	-	-	-	-	-	4
	$000	-	-	-	-	-	519,479
Sulphur, elemental	000 t	-	-	-	-	-	1
	$000	-	-	-	-	-	82
Cement	000 t	..	-	..	..	3 053	3 871
	$000	8,462	-	22,094	15,134	196,200	292,225
Potash (K_2O)	000 t	-	-	-	..	-	-
	$000	-	-	-	..	-	-
Sand and gravel	000 t	3 025	400	7 475	7 600	29 564	69 250
	$000	11,350	1,550	21,300	9,700	60,019	167,400
Stone	000 t	575	-	4 400	2 060	31 173	31 393
	$000	3,335	-	21,250	11,120	142,574	151,887
Asbestos	000 t	50	-	-	-	601	-
	$000	20,442	-	-	-	241,054	-
Silver	t	-	-	-	187	50	489
	$000	-	-	-	52,215	13,836	136,487
Salt	000 t	-	-	..	..	..	6 102
	$000	-	-	..	..	..	136,604
Lead	000 t	-	-	-	73	-	4
	$000	-	-	-	42,362	-	2,437
Clay products	$000	1,150	-	7,750	4,325	21,987	91,725
Lime	000 t	-	-	-	..	265	1 355
	$000	-	-	-	5,340	18,258	90,115
Total leading minerals	$000	918,014	1,550	241,394[1]	479,623[1]	1,319,429[1]	3,982,878[1]
Total, all minerals	$000	927,110	2,235	327,804	550,306	2,236,841	4,565,649
Leading minerals as % of all minerals		99.0	69.4	73.6	87.2	59.0	87.2

[1] Value of salt, potash or iron ore is excluded.

P Preliminary; - Nil; .. Not available; x Less than 1 unit.

Manitoba	Sask.	Alberta	British Columbia	Yukon	N.W.T.	Total Canada
822	11 243	69 213	1 971	–	955	84 311
180,400	2,350,000	15,786,925	430,342	–	167,094	18,938,654
–	1 778	70 869	6 720	–	298	80 181
–	102,466	7,278,483	431,754	–	27,380	7,905,997
9	212	19 240	213	–	–	19 674
950	25,840	2,687,226	33,903	–	–	2,747,919
–	9 745	24 350	23 000	–	–	60 480
–	125,100	458,500	1,101,700	–	–	1,884,100
–	–	–	87	–	–	40 348
–	–	–	3,185	–	–	1,545,783
68	5	–	302	–	–	730
133,986	9,299	–	598,607	–	–	1,445,357
63	4	–	107	x	270	1 039
80,356	5,253	–	135,441	41	341,923	1,316,824
38	–	–	–	–	–	176
266,603	–	–	–	–	–	1,234,961
2 101	190	8	6 441	3 098	12 981	86 044
29,231	2,649	117	89,604	43,098	180,585	1,197,051
–	6	–	–	–	–	10
–	438,181	–	–	–	–	957,660
–	8	7 995	246	–	–	8 250
–	636	851,763	29,174	–	–	881,655
311	..	1 007	990	–	–	9 772
33,145	16,769	118,779	77,239	–	–	780,050
–	..	–	–	–	–	6 923
–	..	–	–	–	–	642,054
12 410	10 200	44 600	31 750	700	6 750	223 724
33,150	26,375	109,000	76,835	1,225	33,350	551,254
1 922	–	180	6 100	–	127	77 930
8,635	–	2,324	36,235	–	795	378,155
–	–	–	93	–	–	744
–	–	–	90,779	–	–	352,275
35	5	–	364	45	34	1 209
9,724	1,325	–	101,485	12,675	9,615	337,362
–	408	1 403	–	–	–	10 043
–	26,817	16,218	–	–	–	225,995
1	–	–	106	2	78	264
394	–	–	61,429	877	44,805	152,304
2,150	4,050	7,550	3,800	–	–	144,487
..	–	147	108	–	–	2 010
5,725	–	10,305	7,300	–	–	137,043
784,449	3,134,760[1]	27,327,190	3,308,812	57,916	805,547	43,756,940
828,459	3,782,600	27,346,016	3,406,471	58,023	843,811	44,875,325
94.7	82.9	99.9	97.1	99.8	95.5	97.5

TABLE 6. CANADA, VALUE OF MINERAL PRODUCTION BY PROVINCES AND TERRITORIES, 1979-85

	1979	1980	1981	1982	1983	1984	1985P
				($ million)			
Alberta	12,899	16,379	17,559	20,913	24,103	26,429	27,346
Ontario	3,265	4,640	4,160	3,148	3,687	4,531	4,566
Saskatchewan	1,874	2,315	2,293	2,313	2,843	3,758	3,783
British Columbia	2,677	2,795	2,822	2,769	2,902	3,346	3,406
Quebec	2,165	2,467	2,420	2,065	2,039	2,167	2,237
Newfoundland	1,125	1,036	1,030	647	807	979	927
Northwest Territories	435	425	447	503	595	777	844
Manitoba	653	803	642	530	733	812	828
New Brunswick	480	373	531	493	506	613	550
Nova Scotia	210	247	269	281	260	304	328
Yukon	299	361	236	169	63	70	58
Prince Edward Island	2	2	2	2	1	2	2
Total	26,084	31,842	32,410	33,831	38,539	43,789	44,875

P Preliminary.

TABLE 7. CANADA, PERCENTAGE CONTRIBUTION OF PROVINCES AND TERRITORIES TO TOTAL VALUE OF MINERAL PRODUCTION, 1979-85

	1979	1980	1981	1982	1983	1984	1985P
Alberta	49.5	51.4	54.2	61.8	62.5	60.4	60.9
Ontario	12.5	14.6	12.8	9.3	9.6	10.4	10.2
Saskatchewan	7.2	7.2	7.0	6.8	7.4	8.6	8.4
British Columbia	10.3	8.8	8.7	8.2	7.5	7.6	7.6
Quebec	8.3	7.7	7.5	6.1	5.3	5.0	5.0
Newfoundland	4.3	3.3	3.2	1.9	2.1	2.2	2.1
Northwest Territories	1.7	1.3	1.4	1.5	1.5	1.8	1.9
Manitoba	2.5	2.5	2.0	1.6	1.9	1.9	1.8
New Brunswick	1.8	1.2	1.6	1.5	1.3	1.4	1.2
Nova Scotia	0.8	0.8	0.8	0.8	0.7	0.7	0.7
Yukon	1.1	1.1	0.7	0.5	0.2	0.2	0.1
Prince Edward Island	0.01	0.01	0.01	0.01	x	x	x
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

P Preliminary; x Amount too small to be expressed.

TABLE 8. CANADA, GROSS DOMESTIC PRODUCT BY INDUSTRY IN CONSTANT 1971 DOLLARS, 1979-85

	1979	1980	1981	1982	1983^r	1984	1985^P
				($ million)			
Goods producing industries							
Agriculture	2,702.8	2,958.9	3,189.4	3,294.9	3,107.9	3,102.6	3,162.1
Forestry	800.0	839.1	768.4	692.1	806.2	841.0	835.5
Fishing and trapping	182.8	172.6	189.8	189.0	181.7	160.6	171.2
Mining[1]	3,347.9	3,492.7	3,271.7	2,916.0	3,040.1	3,473.6	3,528.7
Manufacturing	26,587.7	25,809.1	26,078.1	23,103.4	24,385.6	26,389.6	27,609.4
Construction	7,108.6	7,042.0	7,447.6	6,718.5	6,368.7	6,210.9	6,574.7
Electrical power, gas and water utilities	3,692.6	3,829.3	3,924.3	3,958.0	4,079.6	4,395.4	4,635.5
Total	44,422.4	44,143.8	44,869.3	40,871.9	41,959.8	44,573.7	46,517.1
Service producing industries							
Transportation, storage and communication	12,212.5	12,498.4	12,955.2	12,190.2	12,750.1	13,616.4	14,067.9
Trade	14,998.2	15,023.4	15,212.8	14,181.8	15,377.0	16,339.1	17,478.9
Finance, insurance and real estate	14,768.5	15,388.3	16,013.2	16,107.6	16,475.6	16,871.0	17,759.9
Community, business and personnel services	22,007.6	22,740.3	23,861.0	24,133.6	23,868.6	24,802.0	25,674.9
Public administration and defence	7,886.7	7,985.5	8,141.7	8,403.4	8,542.7	8,653.3	8,726.0
Total	71,873.5	73,635.9	76,183.9	75,016.6	77,014.0	80,281.8	83,707.6
Grand total	116,295.9	117,779.7	121,053.2	115,888.5	118,983.8	124,855.5	130,224.7

[1] Cement, lime, clay and clay products (domestic clays) industries are included under "manufacturing".

P Preliminary; r Revised.

TABLE 9. CANADA'S WORLD ROLE AS A PRODUCER OF CERTAIN IMPORTANT MINERALS, 1986^p

			Rank of Five Leading Countries				
		World	1	2	3	4	5
			Canada	U.S.A.	South Africa	Namibia	Australia
Uranium (U concentrates)[1]	t	38 129	11 163	5 110	5 731	3 690	3 695
	% of world total		29.3	13.4	15.0	9.7	9.7
			Canada	U.S.S.R.	Australia	Peru	U.S.A.
Zinc (mine production)	000 t	6 762	1 207	980	662	568	278
	% of world total		17.9	14.5	9.8	8.4	4.1
			U.S.S.R.	**Canada**	East Germany	West Germany	U.S.A.
Potash (K_2O equivalent)	000 t	28 670	9 500	7 685	3 450	2 300	1 580
	% of world total		33.2	26.8	12.0	8.0	5.5
			U.S.S.R.	**Canada**	Australia	New Caledonia	Indonesia
Nickel (mine production)	000 t	752	175	174	77	58	48
	% of world total		23.3	23.1	10.2	7.7	6.4
			U.S.S.R.	**Canada**	South Africa	Zimbabwe	Brazil
Asbestos	000 t	4 252	2 300	836	170	165	160
	% of world total		54.1	19.7	4.0	3.9	3.8
			U.S.A.	**Canada**	Poland	U.S.S.R.	Mexico
Sulphur, elemental	000 t	33 300	9 400	5 700	5 000	4 000	1 850
	% of world total		28.2	17.1	15.0	12.0	5.6
			Australia	**Canada**	Norway	U.S.S.R.	U.S.A.
Titanium concentrates (ilmenite)	000 t	4 100	1 100	630	435	440	336
	% of world total		26.8	15.4	10.6	10.7	8.2
			U.S.A.	**Canada**	Japan	Spain	France
Gypsum	000 t	81 900	12 990	8 710	6 080	5 625	5 440
	% of world total		15.9	10.6	7.4	6.9	6.6
			U.S.A.	U.S.S.R.	**Canada**	West Germany	Norway
Aluminum (primary metal)	000 t	15 895	4 099	2 300	1 232	777	700
	% of world total		25.8	14.5	7.7	4.9	4.4
			South Africa	U.S.S.R.	**Canada**	U.S.A.	China
Gold (mine production)	t	1 431	640	269	97	64	59
	% of world total		44.7	18.8	6.8	4.5	4.1
			U.S.S.R.	South Africa	**Canada**	Japan	U.S.A.
Platinum group metals (mine production)	kg	220 035	115 000	90 200	10 825	1 300	495
	% of world total		52.1	40.8	4.9	0.6	0.2
			U.S.A.	Chile	U.S.S.R.	**Canada**	Mexico
Molybdenum (Mo content)	000 t	94	46	13	12	11	4
	% of world total		48.9	13.8	12.8	11.7	4.3
			U.S.S.R.	Japan	U.S.A.	**Canada**	Belgium
Cadmium (refined production)	t	19 529	2 750	2 423	2 066	1 780	1 072
	% of world total		14.1	12.4	10.6	9.1	5.5
			U.S.S.R.	Australia	U.S.A.	**Canada**	Peru
Lead (mine production)	000 t	3 428	570	448	333	307	198
	% of world total		16.7	12.9	9.8	9.0	5.8
			Chile	U.S.A.	U.S.S.R.	**Canada**	Zambia
Copper (mine production)	000 t	8 219	1 280	1 091	1 010	712	565
	% of world total		15.6	13.2	12.3	8.7	6.9
			Mexico	Peru	U.S.S.R.	U.S.A.	**Canada**
Silver (mine production)	t	12 789	1 987	1 779	1 600	1 382	1 171
	% of world total		15.5	13.9	12.5	10.8	9.2

[1] Total of western world.

^{p} Preliminary.

TABLE 10. CANADA, CENSUS VALUE ADDED, TOTAL ACTIVITY, MINING AND MINERAL MANUFACTURING INDUSTRIES, 1978-84

	1978	1979	1980	1981	1982	1983	1984
				($ million)			
Mining							
Metallic minerals							
Gold	207.6	322.8	588.8	519.0	566.2	693.6	660.8
Silver-lead-zinc	372.7	671.9	513.6	380.3	351.1	294.2	465.7
Nickel-copper-zinc	1,288.5	2,469.7	2,932.2	2,087.9	1,144.9	1,567.3	2,088.1
Iron	717.0	1,022.2	1,005.0	1,036.0	761.4	648.6	681.1
Uranium	501.7	525.4	559.1	610.1	680.1	496.9	772.5
Miscellaneous metal mines	138.6	179.7	283.3	150.2	73.7	33.2	72.1
Total	3,226.1	5,191.6	5,902.2	4,783.8	3,497.4	3,729.8	4,660.5
Industrial minerals							
Asbestos	401.6	456.8	473.4	431.5	267.1	254.9	252.7
Gypsum	25.9	27.5	26.9	31.3	26.6	35.1	40.2
Peat	33.7	38.8	42.7	47.8	41.1	43.0	47.1
Potash	360.2	613.5	900.4	889.7	488.5	455.4	717.1
Sand and gravel	85.8	91.5	92.0	98.3	75.6	90.3	104.9
Stone	110.2	121.7	123.4	122.5	109.4	119.5	160.1
Miscellaneous nonmetals	122.6	140.1	152.8	171.0	183.5	201.8	240.5
Total	1,139.9	1,489.8	1,811.6	1,791.9	1,192.1	1,200.0	1,562.5
Fuels							
Coal	566.8	658.6	621.6	671.1	838.0	893.1	1,314.2
Petroleum and natural gas	10,078.6	12,554.1	14,917.3	15,924.6	18,899.8	22,171.3	25,008.4
Total	10,645.4	13,212.7	15,538.9	16,595.8	19,753.5	23,064.3	26,322.6
Total mining industry	15,011.4	19,894.1	23,252.7	25,091.4	24,443.0	27,994.1	32,545.7
Mineral manufacturing							
Primary metal industries							
Primary steel	1,924.9	2,424.3	2,537.9	2,750.9	2,149.9	2,464.9	2,930.6
Steel pipe & tube	225.1	280.4	297.6	378.3	320.3	213.4	389.6
Iron foundries	273.8	298.2	266.9	266.0	279.9	326.0	447.7
Smelting and refining	1,587.2	1,481.8	1,976.9	1,888.9	1,493.0	1,912.4	2,236.9
Aluminum rolling, casting and extruding	154.3	249.0	273.5	292.8	289.9	328.2	394.7
Copper and alloy rolling, casting and extruding	95.1	151.5	103.7	129.3	101.6	117.7	147.8
Metal rolling, casting and extruding, nes	136.2	198.9	203.6	210.4	169.2	234.1	323.1
Total	4,396.7	4,983.3	5,660.1	5,836.6	4,803.8	5,596.9	6,879.3
Nonmetallic mineral products industries							
Cement manufacturers	319.9	384.8	357.3	422.2	387.4	407.5	421.9
Lime manufacturers	44.6	49.3	59.5	62.8	60.1	66.2	75.4
Concrete products manufacturers	309.3	328.7	324.6	378.5	309.7	333.6	376.5
Ready-mix concrete manufacturers	317.3	341.6	352.4	438.1	388.6	405.8	397.5
Clay products (domestic clay)	73.6	87.5	84.6	82.0	57.1	78.2	87.7
Clay products (imported clay)	43.1	46.9	51.6	50.9	37.9	37.2	37.3
Glass manufacturers	266.8	294.9	308.1	364.6	330.6	403.8	460.9
Glass products manufacturers	122.9	141.0	143.6	141.0	144.9	209.8	258.1
Abrasive manufacturers	70.6	79.4	92.1	95.9	80.4	91.4	101.9
Other nonmetallic mineral products industries	408.7	460.0	477.5	483.4	426.7	487.6	571.5
Total	1,976.8	2,226.2	2,251.3	2,519.5	2,272.4	2,521.4	2,788.4
Petroleum and coal products industries							
Petroleum refining	1,180.4	1,390.9	1,750.1	2,641.5	2,108.4	2,563.7	2,498.2
Manufacturers of lubricating oil and greases	36.9	38.3	26.7	35.0	31.7	24.8	56.1
Other petroleum and coal products industries	33.1	30.5	36.0	39.3	39.9	52.6	42.1
Total	1,250.4	1,459.8	1,812.8	2,715.8	2,180.1	2,641.1	2,596.4
Total mineral manufacturing	7,481.9	8,669.3	9,724.2	11,062.9	9,256.2	10,759.5	12,264.1
Total mining and mineral manufacturing	22,433.3	28,563.3	32,977.0	36,154.3	33,699.3	38,753.6	44,809.8

nes Not elsewhere specified.

TABLE 11. CANADA, INDEXES OF GROSS DOMESTIC PRODUCT OF INDUSTRIAL PRODUCTION, MINING AND MINERAL MANUFACTURING, 1971-85

(1971=100)	1971	1972	1973	1974	1975	1976^r	1977^r	1978^r	1979^r	1980^r	1981^r	1982^r	1983^r	1984	1985^p
Total industrial production	100.0	107.6	119.0	122.8	115.5	122.6	125.7	129.9	137.9	135.9	136.5	123.0	129.2	140.5	146.7
Total mining	100.0	104.4	117.8	114.0	100.9	102.9	107.0	96.5	106.4	111.0	104.0	92.7	96.6	110.4	112.2
Metals															
All metals^r	100.0	96.3	105.7	101.8	91.2	96.8	101.3	75.1	79.1	87.4	82.2	66.7	70.3	80.7	78.8
Placer gold and gold quartz mines	100.0	90.1	80.0	68.4	67.4	69.1	68.2	65.5	59.8	59.0	65.9	88.6	98.5	107.8	121.6
Iron mines	100.0	78.7	97.4	80.4	71.4	105.0	104.1	48.5	82.2	78.9	77.1	50.8	48.5	58.5	60.7
Other metal mines	100.0	98.6	109.3	109.3	97.7	96.1	102.4	82.7	79.2	91.1	86.4	69.7	74.6	85.2	81.6
Fuels															
All fuels	100.0	114.7	130.1	124.7	112.4	106.2	108.4	109.3	123.0	121.5	113.8	113.5	115.8	128.2	132.8
Coal	100.0	105.4	115.5	116.8	137.5	125.7	136.4	150.0	167.8	184.7	193.6	218.2	239.8	328.3	347.6
Crude oil and natural gas	100.0	115.4	131.2	125.3	110.5	104.8	106.3	106.2	119.6	116.7	107.8	105.7	106.5	113.2	116.3
Nonmetals															
All nonmetals	100.0	99.7	107.8	119.7	88.9	106.2	112.1	106.0	116.5	113.2	109.4	86.6	95.8	115.9	105.3
Asbestos	100.0	101.0	102.1	102.0	63.7	85.9	86.3	63.4	69.9	63.5	59.4	41.7	38.7	38.6	39.1
Mineral manufacturing															
Primary metals	100.0	101.3	112.2	118.7	107.0	104.2	111.9	118.4	121.6	121.0	119.0	97.6	105.8	122.5	124.3
Nonmetallic mineral products	100.0	109.1	119.5	125.2	117.7	121.0	119.4	127.3	134.5	122.7	119.8	96.8	102.0	112.0	119.7
Petroleum and coal products	100.0	115.3	136.1	136.8	130.9	119.7	111.2	112.0	97.7	98.8	100.7	85.2	85.3	86.2	84.7

^{p} Preliminary; ^{r} Revised.

TABLE 12. CANADA, INDEXES OF GROSS DOMESTIC PRODUCT BY INDUSTRIES, 1971-85

(1971=100)	1971	1972	1973	1974	1975	1976ʳ	1977ʳ	1978ʳ	1979ʳ	1980ʳ	1981ʳ	1982ʳ	1983ʳ	1984	1985P
Gross domestic product, all industries	100.0	105.9	114.1	119.3	120.4	126.6	130.1	134.4	139.7	141.5	145.4	139.2	142.9	150.0	156.4
Agriculture	100.0	88.7	96.9	89.5	103.0	109.4	113.8	111.1	100.3	109.8	118.3	122.2	115.3	115.1	117.3
Forestry	100.0	105.7	113.7	112.1	97.8	108.6	111.4	119.3	119.5	125.3	114.8	103.4	120.4	125.6	124.8
Fishing and trapping	100.0	95.7	101.6	90.2	85.8	97.6	109.8	121.4	124.0	117.1	128.8	128.2	123.3	109.0	116.1
Mines (including milling), quarries and oil wells	100.0	104.4	117.6	114.0	100.9	102.9	107.0	96.5	106.4	110.0	104.0	92.7	96.6	110.4	112.2
Electric power, gas and water utilities	100.0	111.1	120.3	130.1	130.5	143.0	150.5	159.2	168.3	174.6	178.9	180.4	186.0	200.4	211.3
Manufacturing	100.0	107.7	119.1	123.4	116.2	123.5	125.9	132.0	139.6	135.5	137.0	121.3	128.1	138.6	145.0
Construction	100.0	103.0	106.1	110.3	116.0	121.6	120.3	118.0	121.6	120.5	127.4	114.9	108.9	106.2	112.5
Transportation, storage and communications	100.0	108.5	117.9	125.0	126.5	134.1	141.1	147.8	157.7	161.9	167.4	160.1	166.9	178.6	185.4
Trade	100.0	109.9	119.8	129.5	132.5	138.6	141.3	147.1	153.0	153.2	155.1	144.6	156.8	166.6	178.2
Community, business and personnel services	100.0	104.8	109.5	115.8	121.1	126.7	128.8	132.9	136.9	141.4	148.4	150.1	148.4	154.2	159.7
Finance, insurance and real estate	100.0	105.3	114.0	120.9	125.9	132.3	140.2	148.0	154.0	160.5	167.0	168.0	171.8	175.9	185.2
Public administration and defence	100.0	104.2	109.7	113.9	119.4	123.0	125.8	129.0	128.2	129.8	132.3	136.6	138.9	140.7	141.8

P Preliminary; ʳ Revised.

TABLE 13. CANADA, GROSS DOMESTIC PRODUCT FOR SELECTED INDUSTRIES BY PROVINCE, 1983

	Nfld.	Prince Edward Island	Nova Scotia	New Brunswick	Quebec	Ontario	Manitoba	Sask.	Alberta	British Columbia	Yukon and N.W.T.	Canada
						($ million)						
Agriculture	20.5	102.4	119.0	110.1	1,208.8	2,530.2	666.5	2,124.1	1,766.7	548.3	..	9,186.6
Forestry	39.5	0.2	27.0	130.3	399.7	303.0	15.3	36.6	36.9	1,306.9	..	2,321.4
Fishing, Hunting and Trapping	116.4	30.0	192.8	55.8	43.8	20.6	13.1	4.3	5.2	140.2	1.1	641.4
Mining[1]	272.2	-	131.8	83.2	791.3	1,613.0	333.5	1,507.8	14,435.6	1,268.0	241.5	20,689.3
Manufacturing	431.4	78.9	1,099.3	952.7	17,587.5	35,131.8	1,635.4	702.5	3,264.6	5,870.1	13.6	66,771.0
Construction	373.3	56.0	517.9	336.6	3,264.2	4,904.0	495.7	847.8	3,217.5	2,296.1	343.5	16,652.6
Electric power, gas and water utilities	242.0	20.4	330.2	439.6	3,770.0	4,071.0	535.8	1,312.3	1,197.6	1,238.5	53.1	12,198.2
Goods-producing industries	1,495.3	287.9	2,418.0	2,106.3	27,005.5	48,656.3	3,695.3	5,535.4	23,924.1	12,674.1	654.8	128,460.5

[1] Cement, lime, clay and clay products (domestic clays) industries are included under "manufacturing".
.. Not available; - Nil.

TABLE 14. CANADA, GROSS DOMESTIC PRODUCT FOR MINING BY PROVINCE, 1977-83

	Nfld.	Prince Edward Island	Nova Scotia	New Brunswick	Quebec	Ontario	Manitoba	Sask.	Alberta	British Columbia	Yukon and N.W.T.	Canada
						($ million)						
1977	346.6	-	113.4	65.6	737.1	1,203.1	125.4	660.5	4,804.2	866.9	155.2	9,064.6
1978	290.7	-	103.9	113.2	708.3	1,217.0	184.9	861.4	5,245.9	924.5	215.2	9,790.3
1979	459.2	-	111.1	206.4	1,175.2	1,519.9	426.4	1,045.3	7,120.6	1,507.3	262.2	13,921.7
1980	410.3	-	120.0	88.6	1,123.6	2,806.1	522.6	1,333.0	9,641.6	1,464.3	368.0	17,851.2
1981	444.6	-	126.8	169.8	1,099.9	2,317.7	397.5	1,329.2	9,782.4	1,484.5	220.4	17,288.7
1982	336.2	-	141.2	122.5	831.2	1,327.5	271.8	1,290.1	11,962.0	1,102.2	221.0	17,697.7
1983	272.2	-	131.8	83.2	791.3	1,613.0	333.5	1,507.8	14,435.6	1,268.0	241.5	20,689.3

- Nil.

TABLE 15. CANADA, VALUE OF EXPORTS OF CRUDE MINERALS AND FABRICATED MINERAL PRODUCTS, 1979-85

	1979	1980	1981	1982	1983	1984	1985P
				($ million)			
Ferrous							
Crude material	1,469.5	1,342.9	1,540.0	1,103.7	1,053.4	1,206.9	1,283.3
Fabricated material	1,947.6	2,358.0	2,664.9	2,295.9	2,011.6	2,666.1	2,842.8
Total	3,417.1	3,701.1	4,205.0	3,399.7	3,065.0	3,873.0	4,125.1
Nonferrous							
Crude material	2,425.1	2,866.6	2,544.0	2,088.3	1,842.7	2,463.2	2,179.1
Fabricated material	3,807.1	6,273.8	5,615.6	4,980.1	5,617.3	6,664.5	6,235.5
Total	6,232.1	9,140.4	8,159.6	7,068.4	7,460.0	9,127.6	8,414.6
Nonmetals							
Crude material	1,715.3	2,305.0	2,618.7	2,132.6	2,146.7	2,767.2	2,990.2
Fabricated material	455.9	412.5	439.7	408.2	422.7	546.8	573.6
Total	2,171.2	2,717.5	3,058.3	2,540.8	2,569.4	3,314.1	3,563.8
Mineral fuels							
Crude material	6,128.9	7,816.8	8,022.0	8,752.4	8,616.9	10,123.5	11,839.1
Fabricated material	1,885.3	2,324.2	2,642.0	2,537.9	2,814.7	3,192.7	3,344.0
Total	8,014.2	10,141.0	10,664.0	11,290.3	11,431.6	13,316.2	15,183.1
Total minerals and products							
Crude material	11,738.8	14,331.4	14,724.6	14,077.0	13,659.7	16,560.8	18,291.7
Fabricated material	8,095.8	11,368.7	11,362.3	10,222.2	10,866.4	13,070.1	12,995.9
Total	19,834.7	25,700.1	26,086.9	24,299.2	24,526.1	29,630.9	31,287.6

P Preliminary.

TABLE 16. CANADA, VALUE OF IMPORTS OF CRUDE MINERALS AND FABRICATED MINERAL PRODUCTS, 1979-85

	1979	1980	1981	1982	1983	1984	1985P
				($ million)			
Ferrous							
Crude material	322.1	354.2	373.2	227.5	285.2	398.9	427.1
Fabricated material	2,533.9	2,329.0	3,303.2	2,113.2	2,004.1	2,701.2	3,253.2
Total	2,856.0	2,683.2	3,676.4	2,340.6	2,289.3	3,100.1	3,680.3
Nonferrous							
Crude material	808.1	1,778.3	1,509.4	1,254.8	1,365.8	1,456.5	1,230.4
Fabricated material	2,122.7	2,784.6	2,433.4	1,861.1	2,359.0	2,576.9	2,886.9
Total	2,930.8	4,562.9	3,942.8	3,116.0	3,724.8	4,033.4	4,117.3
Nonmetals							
Crude material	284.5	329.3	339.3	279.8	267.0	322.2	335.6
Fabricated material	644.7	724.2	805.3	671.6	746.5	884.9	1,045.1
Total	929.2	1,053.5	1,144.6	951.4	1,013.6	1,207.1	1,380.7
Mineral fuels							
Crude material	5,364.3	7,732.3	8,696.9	5,912.6	4,162.0	4,470.8	4,589.5
Fabricated material	394.0	687.7	881.3	862.1	1,051.1	1,652.5	1,677.5
Total	5,758.3	8,420.0	9,578.2	6,774.7	5,213.1	6,123.3	6,267.0
Total minerals and products							
Crude material	6,779.0	10,194.1	10,918.7	7,674.6	6,080.0	6,648.3	6,582.7
Fabricated material	5,695.3	6,525.4	7,423.3	5,507.9	6,160.8	7,815.6	8,862.7
Total	12,474.3	16,719.5	18,342.0	13,182.5	12,240.8	14,464.0	15,445.3

P Preliminary.

TABLE 17. CANADA, VALUE OF EXPORTS OF CRUDE MINERALS AND FABRICATED MINERAL PRODUCTS IN RELATION TO TOTAL EXPORT TRADE, 1975, 1980 AND 1985

	1975		1980		1985P	
	($ million)	(%)	($ million)	(%)	($ million)	(%)
Crude material	7,673.3	22.9	14,331.4	18.7	18,291.7	15.2
Fabricated material	3,557.9	10.6	11,368.7	14.8	12,995.9	10.8
Total	11,231.1	33.5	25,700.1	33.5	31,287.6	26.0
Total exports, all products	33,510.5	100.0	76,680.9	100.0	120,094.8	100.0

P Preliminary.

TABLE 18. CANADA, VALUE OF IMPORTS OF CRUDE MINERALS AND FABRICATED MINERAL PRODUCTS IN RELATION TO TOTAL IMPORT TRADE, 1975, 1980 AND 1985

	1975		1980		1985P	
	($ million)	(%)	($ million)	(%)	($ million)	(%)
Crude material	4,538.2	13.4	10,194.1	15.0	6,582.7	6.4
Fabricated material	2,751.0	8.1	6,525.4	9.6	8,862.7	8.6
Total	7,289.1	21.5	16,719.5	24.6	15,445.3	15.0
Total imports, all products	33,962.0	100.0	67,902.4	100.0	103,278.1	100.0

P Preliminary.

TABLE 19. CANADA, VALUE OF EXPORTS OF CRUDE MINERALS AND FABRICATED MINERAL PRODUCTS BY MAIN GROUPS AND DESTINATION, 1985P

	United States	United Kingdom	EFTA[1]	EEC[2]	Japan	Other Countries	Total
				($ million)			
Ferrous materials and products	3,064.2	208.9	15.7	506.7	97.9	232.8	4,126.1
Nonferrous materials and products	5,109.9	568.3	380.6	643.2	918.8	793.9	8,414.6
Nonmetallic mineral materials and products	1,411.8	41.1	46.5	367.6	132.1	1,564.8	3,563.9
Mineral fuels, materials and products	13,038.1	23.6	34.6	132.5	1,463.8	490.4	15,183.0
Total	22,623.9	841.9	477.3	1,650.0	2,612.6	3,082.0	31,287.6
Percentage of total mineral exports	72.3	2.7	1.5	5.3	8.4	9.9	100.0

[1] European Free Trade Association includes Austria, Norway, Portugal, Sweden, Switzerland, Finland and Iceland. [2] European Economic Community includes Belgium-Luxembourg, France, Italy, Netherlands, West Germany, Greece, Denmark and Ireland.
P Preliminary.

TABLE 20. CANADA, VALUE OF IMPORTS OF CRUDE MINERALS AND FABRICATED MINERAL PRODUCTS BY MAIN GROUPS AND ORIGIN, 1985P

	United States	United Kingdom	EFTA[1]	EEC[2]	Japan	Other Countries	Total
				($ million)			
Ferrous materials and products	2,269.5	163.6	111.0	464.1	330.1	342.0	3,680.3
Nonferrous materials and products	2,980.2	36.5	48.4	240.9	86.7	724.6	4,117.3
Nonmetallic mineral materials and products	950.7	21.7	20.7	211.1	61.0	115.5	1,380.7
Mineral fuels, materials and products	2,050.3	1,207.7	146.1	251.4	0.2	2,611.3	6,267.0
Total	8,250.7	1,429.5	326.1	1,167.6	478.0	3,793.4	15,445.3
Percentage of total mineral imports	53.4	9.3	2.1	7.6	3.1	24.6	100.0

[1] European Free Trade Association includes Austria, Norway, Portugal, Sweden, Switzerland, Finland and Iceland. [2] European Economic Community includes Belgium-Luxembourg, France, Italy, Netherlands, West Germany, Greece, Denmark and Ireland.
P Preliminary.

TABLE 21. CANADA, VALUE OF EXPORTS OF CRUDE MINERALS AND FABRICATED MINERAL PRODUCTS BY COMMODITY AND DESTINATION, 1985P

	United States	United Kingdom	EFTA[1]	EEC[2]	Japan	Other Countries	Total
				($000)			
Petroleum	8,116,210	492	10,112	45,075	7,468	69,503	8,248,860
Natural gas	4,876,005	26	-	-	25,617	1,776	4,903,424
Other ferrous metals	2,611,047	16,545	3,028	100,038	30,708	191,860	2,953,226
Precious metals	1,855,682	101,394	3,014	76,580	177,650	47,359	2,261,679
Aluminum	1,455,104	5,698	12,232	33,573	214,927	340,799	2,062,333
Coal	45,847	23,100	24,487	87,425	1,430,724	419,146	2,030,729
Sulphur	144,296	-	30,159	140,475	10	975,860	1,290,800
Copper	428,930	87,914	61,074	139,324	312,401	149,698	1,179,341
Iron ore	453,147	192,309	12,631	406,657	67,171	40,973	1,172,888
Nickel	416,263	243,225	260,939	127,809	50,180	56,447	1,154,863
Potash	525,651	4,004	845	20,567	79,828	315,454	946,349
Zinc	479,349	53,936	7,701	175,955	24,099	136,217	877,257
Asbestos	72,442	20,528	13,381	80,740	46,135	235,512	468,738
Uranium	98,086	23,446	-	6,241	104,123	-	231,896
All other minerals	1,045,836	69,272	37,683	209,531	41,520	101,393	1,505,235
Total	22,623,895	841,889	477,286	1,649,990	2,612,561	3,081,997	31,287,618

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[1] European Free Trade Association includes Austria, Norway, Portugal, Sweden, Switzerland, Finland and Iceland. [2] European Economic Community includes Belgium-Luxembourg, France, Italy, Netherlands, West Germany, Greece, Denmark and Ireland.
P Preliminary; - Nil.

TABLE 22. CANADA, VALUE OF IMPORTS OF CRUDE MINERALS AND FABRICATED MINERAL PRODUCTS BY COMMODITY AND ORIGIN, 1985P

	United States	United Kingdom	EFTA[1]	EEC[2]	Japan	Other Countries	Total
				($000)			
Petroleum	1,014,049	1,207,600	146,079	250,744	98	2,593,249	5,211,819
Other ferrous metals	1,941,902	163,639	110,956	464,126	330,121	320,481	3,331,225
Precious metals	1,697,274	5,845	7,611	13,677	-	117,289	1,841,696
Aluminum and bauxite	612,149	11,324	7,038	158,957	70,988	310,940	1,171,396
Coal	914,017	-	-	596	114	18,038	932,765
Other nonferrous metals	384,875	7,599	10,112	35,850	6,948	170,301	615,685
Copper	219,007	2,732	7,263	19,435	8,216	93,663	350,316
Iron ore	327,552	-	-	3	-	21,503	349,058
Clays	220,933	6,074	4,606	61,751	15,824	14,382	323,570
Glass products	202,255	2,509	4,333	13,372	16,581	3,477	242,527
Gemstones	45,769	4,884	2,394	77,696	4,877	55,395	191,015
Nickel	66,891	9,035	16,408	12,942	543	32,424	138,243
Natural gas	122,111	68	5	105	-	157	122,446
Phosphate rock	109,620	-	-	-	-	2,793	112,413
All other minerals	372,284	8,220	9,334	58,324	23,718	39,275	511,155
Total	8,250,688	1,429,529	326,139	1,167,578	478,028	3,793,367	15,445,329

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[1] European Free Trade Association includes Austria, Norway, Portugal, Sweden, Switzerland, Finland and Iceland. [2] European Economic Community includes Belgium-Luxembourg, France, Italy, Netherlands, West Germany, Greece, Denmark and Ireland.
P Preliminary; - Nil.

TABLE 23. CANADA, PHYSICAL VOLUME OF IMPORT TRADE FOR SELECTED COMMODITIES, 1979-85

	Units of Weight	1979	1980	1981	1982	1983	1984	1985^{P}
Crude materials								
Metals								
Iron ore	t	5 912 581	5 875 292	5 794 604	3 359 286	4 013 109	4 946 892	5 800 194
Bauxite ore	t	2 149 636	3 504 368	2 734 771	2 574 762	2 329 910	2 451 542	2 074 205
Alumina	t	952 584	983 972	1 020 568	939 282	1 063 181	1 349 213	1 544 006
Manganese ore	t	45 150	95 161	119 748	71 658	42 260	77 545	102 188
Nonmetals								
Phosphate rock	t	3 341 039	3 816 514	3 245 430	2 477 187	2 625 389	3 169 613	2 637 671
Limestone, crushed	t	3 215 717	2 418 330	2 526 863	1 485 420	1 799 861	1 944 046	2 071 649
Salt & brine	t	1 275 627	1 151 203	1 254 985	1 526 873	777 310	1 053 211	1 255 490
Sand & gravel	t	1 201 915	1 209 582	1 446 864	1 179 279	878 614	1 266 983	1 111 801
Silica sand	t	1 651 890	1 200 237	1 142 875	788 764	982 662	1 076 082	983 270
Clay, ground & unground	t	445 231	403 282	413 046	345 389	368 999	403 485	461 540
Bentonité	t	638 307	471 684	311 255	238 031	187 228	377 054	346 092
Fluorspar	t	167 904	223 940	173 599	126 594	141 928	166 709	111 726
Fuels								
Coal	t	17 381 794	15 719 025	14 687 202	15 488 032	14 509 685	19 060 700	14 998 758
Petroleum, crude	m^3	35 330 535	32 710 030	30 752 166	19 671 110	14 603 436	14 849 660	15 862 657
Fabricated materials								
Metals								
Steel								
sheets & strips	t	1 039 054	582 233	1 717 118	540 409	535 132	699 787	1 010 362
pipes & tubes	t	285 144	322 121	364 868	249 582	217 043	316 064	455 341
bars & rods	t	300 069	189 853	340 773	219 619	277 256	407 499	363 999
structural shapes	t	273 111	207 657	362 890	120 368	162 136	229 938	232 570
castings & forgings	t	139 095	129 363	118 476	70 125	92 533	121 683	95 287
Aluminum sheets, rods, nes	t	168 125	128 150	139 356	125 611	152 597	231 629	236 465
Ferroalloys	t	167 232	118 516	117 905	64 662	71 565	106 563	85 894
Nonmetals								
Phosphate fertilizers	t	381 887	248 328	307 220	249 833	360 304	340 177	447 978
Cement	t	248 422	223 247	721 216	231 834	238 269	236 233	372 796
Fire bricks	t	227 156	236 205	187 016	132 601	154 754	176 767	167 192
Fuels								
Fuel oil	000 L	871 425	1 617 606	1 256 790	1 571 003	1 446 255	2 399 280	2 073 480
Coke	t	1 366 182	1 311 535	1 436 068	1 051 315	1 354 844	1 546 991	1 676 270

P Preliminary; nes Not elsewhere specified.

TABLE 24. CANADA, PHYSICAL VOLUME OF EXPORT TRADE FOR SELECTED COMMODITIES, 1979-85

	Unit of Weight	1979	1980	1981	1982	1983	1984	1985P
Crude material								
Metals								
Iron, ores	t	48 849 270	39 020 922	41 451 255	27 281 255	25 527 958	30 737 459	32 216 269
Zinc, ores & concentrates	t	598 279	435 831	516 216	457 757	626 178	539 633	409 744
Copper, ores & concentrates	t	315 211	286 076	276 816	257 934	313 796	339 054	296 927
Lead, ores & concentrates	t	151 485	147 008	146 307	106 744	85 459	72 937	62 606
Nonmetals								
Potash	t	10 630 583	10 554 060	10 067 995	7 221 493	9 411 905	11 214 972	9 802 460
Sulphur, crude	t	5 154 831	6 850 143	7 309 175	6 111 418	5 670 278	7 326 847	7 848 378
Gypsum	t	5 474 764	4 960 240	5 094 845	4 775 755	5 187 032	6 224 574	5 880 430
Salt and brine	t	1 822 120	1 655 768	1 507 698	1 721 883	1 914 627	2 530 038	2 263 077
Limestone, crushed	t	2 296 295	2 214 489	1 758 290	1 517 491	1 390 795	1 216 677	1 195 938
Asbestos, crude & fibers	t	1 461 042	1 217 737	1 062 185	880 684	753 911	795 853	721 513
Crude refractory materials	t	1 023 734	803 892	629 781	40 839	241 131	579 488	534 579
Nepheline syenite	t	471 056	448 468	476 275	414 785	398 299	387 069	351 032
Sand and gravel	t	323 639	383 533	318 633	168 690	95 633	109 812	241 791
Fuels								
Coal	t	13 852 848	14 310 782	16 285 068	15 528 535	16 974 355	24 354 888	27 572 021
Natural gas	000 m^3	28 047 648	22 963 134	21 689 772	22 074 597	19 296 956	21 061 258	25 347 192
Fabricated materials								
Metals								
Aluminum, pig ingots	t	551 957	784 720	725 452	896 377	925 402	834 193	1 050 789
Iron, pig ingots	t	255 523	562 351	466 358	485 616	348 278	392 134	574 109
Zinc, pig ingots	t	429 352	472 148	453 538	470 395	500 448	529 659	555 616
Copper, refinery shapes	t	191 211	335 200	263 052	232 624	298 527	345 979	277 117
Lead, pig ingots	t	117 992	126 538	119 816	146 130	147 263	124 149	113 989
Nonmetals								
Cement	t	2 288 822	1 550 562	1 578 684	1 752 141	1 512 562	2 113 382	2 485 700
Peat	t	358 267	390 457	326 828	356 028	396 879	460 600	446 521
Lime, quick & hydrated	t	490 863	403 166	432 853	281 251	215 941	186 748	194 091
Fuels								
Fuel oil	000 L	4 654 162	4 273 510	3 846 906	2 721 922	3 825 520	4 420 429	4 668 952
Propane gas, liquified	000 L	4 858 175	3 879 915	3 867 950	4 513 284	3 534 562	3 880 987	3 224 326
Butane gas, liquified	000 L	2 926 459	2 563 406	3 137 545	3 572 545	3 011 710	3 280 303	3 098 296
Gasoline	000 L	913 271	706 539	600 969	536 268	1 240 028	1 589 258	2 375 028
Coke	t	354 016	470 496	392 662	235 924	106 147	171 524	215 038

P Preliminary.

TABLE 25. CANADA, APPARENT CONSUMPTION[1] OF SOME MINERALS AND RELATION TO PRODUCTION[2], 1983-85

	Unit of Measure	1983			1984			1985P		
		Apparent Consumption	Production	Consumption as % of Production	Apparent Consumption	Production	Consumption as % of Production	Apparent Consumption	Production	Consumption as % of Production
Asbestos	t	104 047	857 504	12.1	41 127	836 654	4.9	52 000	743 678	7.0
Cement	t	6 198 902	7 506 968	82.6	7 363 108	9 240 257	79.7	7 710 000	9 771 764	78.9
Gypsum	t	2 784 785	7 870 878	35.4	1 682 317	7 775 082	21.6	2 290 000	8 383 538	27.3
Iron ore	t	11 443 829	32 958 678	34.7	14 139 340	39 929 907	35.4	13 700 000	40 348 271	34.0
Lime		2 038 588	2 231 685	91.3	2 087 214	2 249 114	92.8	1 840 000	2 009 700	91.6
Quartz silica	t	3 182 424	2 303 451	138.2	3 619 211	2 658 932	136.1	3 350 000	2 537 884	132.0
Salt	t	7 502 020	8 602 383	87.2	8 758 572	10 235 399	85.6	9 170 000	10 042 963	91.3

[1] "Apparent consumption" is production, plus imports, less exports. [2] "Production" refers to producers' shipments.
P Preliminary.

TABLE 26. CANADA, REPORTED CONSUMPTION OF MINERALS AND RELATION TO PRODUCTION, 1982-84

	Unit of Measure	1982			1983			1984^p		
		Consumption	Production	Consumption as % of Production	Consumption	Production	Consumption as % of Production	Consumption	Production	Consumption as % of Production
Metals										
Aluminum	t	273 523	1 064 795	25.7	337 580	1 091 213	30.9	411 772	1 221 985	33.7
Antimony	kg	161 034	..	..	217 352	385 358	56.4	356 272	553 875	64.3
Bismuth	kg	10 074	189 132	5.3	7 241	253 023	2.9	9 398	166 177	5.7
Cadmium	kg	33 818	886 055	3.8	32 885	1 193 379	2.8	28 810	1 605 286	1.8
Chromium (chromite)	t	15 330	-	..	15 682	-	..	21 059	-	..
Cobalt	kg	80 953	1 274 484	6.4	100 996	1 409 626	7.2	112 972	2 123 333	5.3
Copper^1	t	130 559	612 455	21.3	170 443	653 040	26.1	205 472	721 826	28.5
Lead^2	t	103 056^r	272 187	37.8	94 840	271 961	34.8	130 547	264 301	49.3
Magnesium	t	5 005	..	..	5 568	..	..	6 830	..	..
Manganese ore	t	130 826	-	..	96 697	-	..	108 913	-	..
Mercury	kg	28 689^r	-	..	37 192	-	..	42 013	-	..
Molybdenum (Mo content)	t	671	13 961	4.8	490	10 194	4.8	..	11 557	..
Nickel	t	6 723	88 581	7.6	5 010	125 022	4.0	7 285	173 725	4.2
Selenium	kg	10 469	222 323	4.7	11 706	265 672	4.4	9 845	463 188	2.1
Silver	kg	180 459	1 313 630	13.7	283 349	1 197 031	23.6	299 440	1 326 720	22.6
Tellurium	kg	..	18 423	..	..	16 391	..	..	18 964	..
Tin	t	3 528	135	2 613.3	3 381	140	2 415.0	4 086	209	1 955.0
Tungsten (W content)	kg	485 606	3 029 730	16.0	503 651	1 125 558	44.7	659 665	4 195 785	15.7
Zinc	t	100 233	965 607	10.4	116 257	987 713	11.8	150 528	1 062 701	14.2
Nonmetals										
Barite	t	24 359	23 552	103.4	66 086	45 465	145.4	78 799	64 197	122.7
Feldspar	t	2 790	-	..	2 213	-	..	2 106	-	..
Fluorspar	t	173 431	-	..	163 444	-	..	176 852	-	..
Mica	kg	2 745	..	..	3 002	..	..	2 474	..	..
Nepheline syenite	t	85 373	550 480	15.5	94 634	523 249	18.1	91 555	520 640	17.6
Phosphate rock	t	2 581 671	-	..	2 922 484	-	..	2 053 486	-	..
Potash (K_2O)	t	228 460	5 308 532	4.3	229 093	6 293 747	3.6	213 896	7 527 347	2.8
Sodium sulphate	t	191 988^r	547 208	35.1	190 625	453 939	42.0	229 295	389 086	58.9
Sulphur	t	935 888^r	6 945 183	13.5	1 089 230	7 309 409	14.9	1 204 850	9 197 254	13.1
Talc, etc.	t	38 633	70 523	54.8	39 497	97 030	40.7	59 189	122 992	48.1
Fuels										
Coal	000 t	41 500	42 906	96.7	41 588	44 787	92.9	50 152	57 402	87.4
Natural gas^3	million m^3	46 143	69 288	66.6	43 832	72 229	60.7	47 590	78 266	60.8
Crude oil^4	000 m^3	86 528	79 255	109.2	81 706	78 751	103.8	82 524	83 680	98.6

Note: Unless otherwise stated, consumption refers to reported consumption of refined metals or nonmetallic minerals by consumers. Production of metals, in most cases, refers to production in all forms, and includes the recoverable content of ores, concentrates, matte, etc., and metal content of primary products recoverable at domestic smelters and refineries. Production of nonmetals refers to producers' shipments. For fuels, production is equivalent to actual output less waste.

[1] Consumption defined as producers' domestic shipments of refined metal. [2] Consumption includes primary and secondary refined metal. [3] Consumption defined as domestic sales. [4] Consumption defined as refinery receipts.

^{p} Preliminary; ^{r} Revised; - Nil; .. Not available or not applicable.

TABLE 27. CANADA, DOMESTIC CONSUMPTION OF PRINCIPAL REFINED METALS IN RELATION TO REFINERY PRODUCTION[1], 1978-84

	Unit of measure	1978	1979	1980	1981	1982	1983	1984P
Copper								
Domestic consumption[2]	t	228 694	210 689	195 124	216 759	130 559	170 443	205 472
Production	t	446 278	397 263	505 238	476 655	337 780	464 333	504 262
Consumption of production	%	51.2	53.0	38.6	45.5	38.6	36.7	40.7
Zinc								
Domestic consumption[3]	t	121 375	131 317	116 618	113 061	100 233	116 257	150 528
Production	t	495 243	580 449	591 565	618 650	511 870	617 033	682 976
Consumption of production	%	24.5	22.6	19.7	18.3	19.6	26.9	22.0
Lead								
Domestic consumption[3]	t	100 762	98 018r	106 836r	110 931r	103 056r	94 840	130 547
Production	t	194 054	183 769	162 463	168 450	174 310	178 043	174 987
Consumption of production	%	51.9	53.3	65.8	65.9	59.1	53.3	74.6
Aluminum								
Domestic consumption[4]	t	380 291	398 834	329 400	336 989	273 523	337 580	411 772
Production	t	1 048 469	860 287	1 068 197	1 115 691	1 064 795	1 091 213	1 221 985
Consumption of production	%	36.3	46.4	30.8	30.2	25.7	30.9	33.7

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[1] Production of refined metal from all sources, including metal derived from secondary materials at primary refineries. [2] Producers' domestic shipments of refined metal. [3] Consumption of primary and secondary refined metal, reported by consumers. [4] Consumption of primary refined metal, reported by consumers.
P Preliminary; r Revised.

TABLE 28. AVERAGE ANNUAL PRICES[1] OF SELECTED MINERALS, 1979-85[2]

	Unit of Measure	1979	1980	1981	1982	1983	1984	1985
Aluminum, major U.S. producer[3]	cents/lb.	59.395	69.566	57.274	44.966	65.342	56.526	47.850
Antimony, New York dealer	$/lb.	1.407	1.508	1.355	1.072	0.913	1.512	1.311
Asbestos, No. 4 T cement fibre	Cdn $/st	687.000	769.000	850.000	876.000	1083.000	1083.000	982.481
Bismuth, U.S. producer	$/lb.	3.011	2.637	2.044	2.300	2.300	4.141	6.500
Cadmium, U.S. producer	$/lb.	2.760	2.843	1.927	1.113	1.129	1.693	1.208
Calcium, metal crowns	$/lb.	1.868	2.502	2.831	3.050	3.050	3.099	3.504
Chrome, U.S. metal, 9% carbon	$/lb.	3.375	4.017	4.450	4.450	4.450	4.450	4.450
Cobalt, metal, shot/cathode/250 kg	$/lb.	24.583	25.000	21.429[7]	12.500	12.500	12.417	11.700
Columbium, pyrochlore	$/lb.	2.550	2.550	3.250	3.250	3.250	3.250	3.209
Copper, electrolytic cathode	Cdn $/lb.	1.076	1.178	1.004	0.885	0.948	0.858	0.911
Gold, London[4]	Cdn $/troy oz.	359.289	716.087	551.178	465.102	520.792	466.781	433.227
Iridium, major producer	$/troy oz.	258.333	505.833	600.000	600.000	600.000	600.000	600.000
Iron ore, taconite pellets	cents/ltu	63.966	69.562	80.073	80.500	80.500	80.500	80.500
Lead, producer	Cdn cents/lb.	59.920	49.350	44.520	32.887	26.770	33.517	26.179
Manganese, U.S. metal, regular	cents/lb.	58.333	65.267	70.000	86.274	67.583	73.542	80.000
Magnesium, U.S. primary ingot	cents/lb.	105.758	116.667	130.250	134.000	136.508	145.500	148.000
Mercury, New York	$/flask (76 lb.)	281.096	389.447	413.885	370.934	322.443	314.381	310.957
Molybdenum, dealer, oxide	$/lb.	23.141	9.359	6.400	4.100	3.635	3.557	3.247
Nickel, major producer, cathode	$/lb.	2.707	3.415	3.429	3.200	3.200	3.200	3.200
Osmium, New York dealer	$/troy oz.	130.000	130.000	130.000	130.000	133.113	466.479	913.125
Palladium, major producer	$/troy oz.	113.143	213.975	129.500	110.000	130.000	146.667	126.905
Platinum, major producer	$/troy oz.	351.649	439.425	475.000	475.000	475.000	475.000	475.000
Potash, K_2O, coarse, major producer	cents/stu	100.417	112.667	120.750	119.615	116.000	107.638	96.774
Rhodium, major producer	$/troy oz.	737.500	764.583	639.583	600.000	600.000	627.500	892.708
Ruthenium, major producer	$/troy oz.	45.750	45.000	45.000	45.000	45.000	45.000	..
Selenium, New York dealer	$/lb.	11.086	8.331	4.115	3.766	3.722	8.995	7.248
Silver, Handy & Harman, Toronto	Cdn $/troy oz.	12.974	24.099	12.617	9.831	14.154	10.828	8.674
Sulphur, elemental, major producer[5]	Cdn $/mt	25.260	31.510	60.330	68.300	60.170	69.222	100.770
Tantalum ore, spot	$/lb.	66.671	106.982	63.292	31.540	23.146	29.438	26.292
Tellurium, major producer, slab	$/lb.	20.000	19.500	..	..	..	..	..
Tin	Cdn $/lb.	8.898	10.008	8.893	8.144	8.103	8.180	7.181
Titanium, slag	$/lt	110.000	115.000	135.000	150.000	150.000	150.000	150.000
Tungsten, U.S. hydrogen-red	$/lb.	13.900	13.900	13.900	13.350	13.100	13.100	13.100
Uranium, U_3O_8[6]	Cdn $/lb.	50.004	51.927	42.311	44.234	38.500	34.600	35.380
Vanadium, pentoxide, metallurgical	$/lb.	3.050	3.050	3.250	3.350	3.350	3.350	4.100
Zinc, special high grade	Cdn cents/lb.	43.717	44.050	54.240	49.167	52.632	63.823	56.876

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[1] Prices, except for those noted, are in United States currency. [2] Sources: Alberta Energy Resource Industries Monthly Statistics, Engineering and Mining Journal, Metals Week and Northern Miner. [3] Starting 1981, London Metal Exchange. [4] Average afternoon fixings of London bullion dealers, converted to Canadian dollar. [5] Starting 1980, North American deliveries. [6] From EMR publications on assessment of Canada's uranium supply and demand; series EP 79-3 to EP 85-3. [7] Seven-month average.

.. Not available.

TABLE 29. CANADIAN AVERAGE ANNUAL PRICES OF SELECTED MINERALS, 1979-85[1]

	Unit of Measure	1979	1980	1981	1982	1983	1984	1985
Aluminum, major U.S. producer[2]	$/kg	1.534	1.793	1.514	1.223	1.775	1.614	1.440
Antimony, New York dealer	$/kg	3.634	3.887	3.582	2.917	2.481	4.316	3.947
Asbestos, No. 4 T cement fibre	$/t	757.288	847.677	936.964	965.625	1,193.800	1,193.800	1,083.000
Bismuth, U.S. producer	$/kg	7.777	6.796	5.403	6.258	6.248	11.821	19.568
Cadmium, U.S. producer	$/kg	7.128	7.327	5.094	3.028	3.067	4.833	3.637
Calcium, metal crowns	$/kg	4.825	6.448	7.483	8.298	8.287	8.846	10.549
Chrome, U.S. metal, 9% carbon	$/kg	8.717	10.353	11.763	12.107	12.090	12.703	13.396
Cobalt, metal, shot/cathode/250 kg	$/kg	63.492	64.430	56.610[6]	34.009	33.961	35.446	35.222
Columbium, pyrochlore	$/kg	6.586	6.572	8.591	8.842	8.830	9.278	9.660
Copper, electrolytic cathode	$/kg	2.372	2.597	2.213	1.951	2.089	1.892	2.008
Gold, London[3]	$/g	11.551	23.023	17.721	14.953	16.744	15.007	13.929
Iridium, major producer	$/g	9.730	19.011	23.129	23.806	23.773	24.978	26.341
Iron ore, taconite pellets	$/mtu	73.754	80.034	94.490	97.776	97.638	102.588	109.923
Lead, producer	¢/kg	132.101	108.798	98.150	72.503	59.018	73.892	57.715
Manganese, U.S. metal, regular	$/kg	1.507	1.682	1.850	2.347	1.836	2.099	2.408
Magnesium, U.S. primary ingot	$/kg	2.731	3.007	3.443	3.646	3.709	4.154	4.455
Mercury, New York	$/kg	9.553	13.206	14.395	13.279	11.527	11.808	12.317
Molybdenum, dealer, oxide	$/kg	59.767	24.120	16.917	11.155	9.876	10.154	9.775
Nickel, major producer, cathode	$/kg	6.992	8.801	9.064	8.706	8.695	9.136	9.633
Osmium, New York dealer	$/g	4.896	4.886	5.011	5.158	5.274	19.420	40.088
Palladium, major producer	$/g	4.262	8.042	4.992	4.364	5.151	6.[illegible]36	5.571
Platinum, major producer	$/g	13.245	16.515	18.310	18.847	18.820	19.774	21.853
Potash, K_2O, coarse, major producer	$/t	87.445	87.110	95.754	97.632	94.547	92.180	87.189
Rhodium, major producer	$/g	27.778	28.736	24.655	23.806	23.773	26.123	39.192
Ruthenium, major producer	$/g	1.723	1.691	1.735	1.785	1.783	1.873	..
Selenium, New York dealer	$/kg	28.632	21.471	10.877	10.246	10.112	25.677	21.820
Silver, Handy & Harman, Toronto	$/kg	417.124	774.801	405.646	316.074	455.062	348.160	269.791
Sulphur, elemental, major producer[4]	$/t	25.260	31.510	60.330	68.300	60.170	69.222	100.770
Tantalum ore, spot	$/kg	172.196	275.483	167.300	85.811	62.885	86.034	79.150
Tellurium, major producer, slab	$/kg	51.655	50.255	..	..	..	..	..
Tin	$/kg	19.617	22.064	19.606	17.954	17.864	18.035	15.831
Titanium, slag	$/t	126.832	132.312	159.306	182.191	181.933	194.225	201.591
Uranium, U[5]	$/kg	130.000	135.000	110.000	115.000	100.000	90.000	92.000
Vanadium, pentoxide, metallurgical	$/kg	7.877	7.861	8.591	9.114	9.102	9.564	12.343
Zinc, special high grade	$/kg	0.964	0.971	1.196	1.084	1.160	1.407	1.254

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[1] Sources: Alberta Energy Resource Industries Monthly Statistics, Engineering and Mining Journal, Metals Week and Northern Miner.
[2] Starting 1981, London Metal Exchange. [3] Average afternoon fixings of London bullion dealers, converted to Canadian dollar. [4] Starting 1980, North American deliveries. [5] From EMR publications on assessment of Canada's uranium supply and demand; series EP 79-3 to EP 85-3.
[6] Seven-month average.
.. Not available.

TABLE 30. CANADA, MINERAL PRODUCTS INDUSTRIES, SELLING PRICE INDEXES, 1979-85

(1971 = 100)	1979	1980	1981	1982	1983	1984	1985P
Iron and steel products industries							
Agricultural implements industry	206.0	224.9	260.2	293.1	310.9	320.7	329.2
Hardware, tool and cutlery manufacturers	207.3	238.4	268.2	296.0	308.3	326.3	344.1
Heating equipment manufacturers	188.0	213.2	236.5	267.7	280.4	291.0	308.4
Primary metal industries	258.8	308.3	312.6	310.7	320.6	324.2	317.9
Iron and steel mills	233.7	261.7	290.3	314.2	319.2	326.1	330.7
Steel pipe and tube mills	248.1	276.9	322.1	362.6	359.7	363.7	368.5
Iron foundries	223.3	243.2	261.8	268.9	272.4	273.6	284.5
Wire and wire products manufacturers	206.4	226.9	242.4	249.6	252.7	265.9	272.8
Nonferrous metal products industries							
Aluminum rolling, casting and extruding	234.0	271.0	292.6	290.7	291.7	335.1	316.0
Copper and alloy, rolling, casting and extruding	201.8	219.7	205.8	193.0	206.3	192.8	195.7
Jewellery and silverware manufacturers	507.3	871.3	676.1	609.5	699.1	645.7	623.3
Metal rolling, casting and extruding, nes	310.4	327.3	325.7	314.0	324.3	345.6	329.4
Nonmetallic mineral products industries							
Abrasives manufacturers	255.3	290.6	325.1	361.8	371.0	372.7	381.3
Cement manufacturers	233.2	265.7	308.0	359.7	374.2	385.1	403.6
Clay products from imported clay	190.1	215.2	251.9	278.0	290.6	300.7	310.8
Glass and glass products manufacturers	173.4	197.0	223.2	250.2	259.7	268.1	274.2
Lime manufacturers	292.7	338.3	396.1	453.2	514.4	557.0	556.2
Concrete products manufacturers	200.1	222.5	259.4	296.7	310.6	320.7	335.6
Clay products from domestic clay	214.3	226.9	243.0	269.9	287.8	318.1	344.6
Petroleum and coal products industries	321.3	404.6	551.7	634.4	674.8	704.4	748.5
Petroleum refineries	325.8	410.6	559.8	643.7	684.7	714.7	759.5
Mixed fertilizers	229.0	280.3	289.5	294.5	284.2	296.7	292.9

nes Not elsewhere specified; P Preliminary.

TABLE 31. CANADA, PRINCIPAL STATISTICS OF THE MINERAL INDUSTRY[1], 1986

	Mining Activity								Total Activity[2]		
		Production and Related Workers			Costs						
	Establishments (number)	Employees (number)	Person-hours Paid (000)	Wages ($000)	Fuel and Electricity ($000)	Materials and Supplies ($000)	Value of Production ($000)	Value Added ($000)	Employees (number)	Salaries and Wages ($000)	Value Added ($000)
Metals											
Gold	66	6 773	14 112	225,635	57,587	244,347	964,174	662,240	8 450	283,791	660,756
Silver-lead-zinc	16	3 575	7 633	113,661	57,262	539,011	1,068,161	471,887	5 165	200,128	465,677
Nickel-copper-zinc	32	17 710	34 372	552,466	208,580	1,449,459	3,651,271	1,993,732	24 000	782,519	2,008,188
Iron	13	5 696	11 607	193,212	206,237	512,239	1,423,122	686,646	7 863	277,695	681,379
Uranium	5	4 716	8 960	167,568	63,568	161,618	1,000,791	775,625	6 209	234,699	772,538
Misc. metal mines	6	713	1 486	23,635	11,455	21,315	106,818	72,069	976	35,969	72,060
Total	116	39 181	78 150	1,296,157	604,169	2,947,989	8,212,337	4,660,179	52 683	1,814,801	4,660,546
Industrials											
Asbestos	9	3 298	6 329	92,481	49,872	57,766	366,668	257,051	4 177	126,238	252,681
Gypsum	10	653	1 477	14,538	6,017	15,716	62,015	40,282	770	17,698	40,159
Peat	57	1 133	2 208	17,005	3,335	13,543	63,502	46,624	1 369	22,206	47,098
Potash	11	3 211	6 828	107,057	112,866	110,701	925,917	702,352	4 508	156,297	717,079
Sand and gravel	81	969	2 110	24,401	13,639	31,521	142,968	97,788	1 306	33,656	106,915
Stone	114	1 734	3 789	45,199	24,862	61,570	240,989	154,577	2 256	58,462	160,095
Misc. nonmetals	65	2 030	4 318	56,297	35,051	53,051	326,569	235,717	2 874	80,282	240,505
Total	327	13 008	27 057	356,828	246,370	343,848	2,124,628	1,534,391	17 258	494,841	1,562,535
Fuels											
Coal	29	8 711	17 964	324,024	121,394	277,345	1,716,223	1,317,485	11 905	457,970	1,314,207
Oil, crude and natural gas	909	9 788	19 624	347,994	232,076	721,791	25,922,852	24,968,985	36 580	1,420,379	25,008,437
Total	938	18 499	37 588	672,018	353,470	999,136	27,639,075	26,286,470	48 485	1,878,349	26,322,644
Total mineral industry	1 381	70 688	142 795	2,325,003	1,204,009	4,290,972	37,976,019	32,481,039	118 426	4,187,990	32,545,725

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[1] Cement manufacturing, lime manufacturing, clay and clay products (domestic clays) are included in the mineral manufacturing industry.
[2] Total activity includes sales and head offices.

TABLE 32. CANADA, PRINCIPAL STATISTICS OF THE MINERAL MANUFACTURING INDUSTRIES, 1984

	Mineral Manufacturing Activity								Total Activity[1]		
		Production and Related Workers			Costs						
	Establishments	Employees	Person-hours Paid	Wages	Fuel and Electricity	Materials and Supplies	Value of Shipments	Value Added	Employees	Salaries and Wages	Value Added
	(number)	(number)	(000)	($000)	($000)	($000)	($000)	($000)	(number)	($000)	($000)
Primary metal industries											
Primary steel	59	37 482	80 808	1,252,414	505,225	4,077,613	7,442,664	2,927,161	48 899	1,675,239	2,939,565
Steel pipe and tube	38	4 330	9 386	131,998	27,359	732,604	1,115,912	388,557	5 682	168,266	389,615
Iron foundries	105	6 603	14 098	167,465	41,267	269,575	762,010	461,195	7 911	212,447	447,662
Smelting and refining	30	21 465	43 433	710,607	414,631	1,871,933	4,382,732	2,231,448	31 752	1,128,301	2,236,923
Aluminum rolling, casting and extruding	72	4 830	10 783	139,640	38,870	1,004,729	1,442,440	393,449	6 661	206,516	396,667
Copper and alloy rolling, casting and extruding	39	2 469	5 099	59,913	14,688	322,161	483,967	151,740	2 971	75,721	147,781
Metal rolling, casting and extruding, nes	98	4 275	9 265	102,406	26,535	449,123	801,777	322,851	5 276	133,553	323,065
Total	441	81 454	172 799	2,564,420	1,068,535	8,727,737	16,431,472	6,856,421	108 950	3,598,083	6,879,278
Nonmetallic mineral products industries											
Cement	26	2 190	5 061	77,515	107,661	127,863	696,179	417,191	3 771	125,475	421,899
Lime	15	643	1 392	19,966	51,366	22,026	147,427	74,557	876	27,848	75,999
Concrete pipe	52	1 223	2 640	29,169	5,970	171,016	171,016	96,468	1 656	42,585	97,413
Structural concrete products	55	1 868	3 880	47,281	5,298	196,873	196,873	118,067	2 386	63,776	117,233
Other concrete products	322	2 863	5 969	57,863	16,519	289,108	289,108	156,298	3 619	79,191	161,811
Ready-mix concrete	584	6 868	16 236	174,220	69,792	659,315	1,061,569	372,038	8 807	229,411	397,491
Gypsum products	27	1 430	2 901	33,565	12,988	149,121	335,817	154,364	2 323	59,533	159,173
Clay products (domestic)	96	1 373	2 864	27,890	28,638	22,626	138,406	87,076	1 817	41,276	87,671
Clay products (imported)	67	1 021	1 990	17,298	4,767	19,263	60,434	36,550	1 253	23,266	37,311
Primary glass	18	6 121	12 290	156,937	73,867	187,720	718,281	462,173	8 031	219,716	460,891
Glass products	142	3 937	8 165	93,225	13,681	251,698	522,051	257,716	4 723	113,598	258,159
Abrasives	20	1 470	3 210	36,990	32,809	101,906	232,985	98,615	1 969	52,496	101,931
Refractory products	28	785	1 651	18,612	6,885	70,266	151,868	79,225	1 433	30,362	86,087
Mineral insulating products	60	1 990	4 033	50,621	32,964	68,456	289,830	131,586	3 257	95,065	186,372
Other nonmetallic mineral products	171	2 320	4 790	47,673	10,956	163,996	235,272	135,425	3 002	66,772	141,856
Total	1 621	36 155	75 029	881,406	511,459	2,466,115	5,266,406	2,676,838	48 895	1,278,223	2,788,985
Petroleum and coal products industries											
Petroleum refining products	53	5 717	12 736	241,616	311,666	20,512,765	22,958,412	2,527,139	15 867	689,636	2,498,216
Lubricating oils & greases	28	516	1 069	14,100	4,130	182,162	235,898	50,076	896	26,367	56,111
Other petroleum & coal products	59	307	599	7,113	5,301	99,661	142,470	37,979	521	13,230	42,068
Total	120	6 540	14 402	262,827	321,095	20,794,588	23,336,800	2,615,996	17 284	728,833	2,596,393
Total, mineral manufacturing industries	2 182	124 147	262 222	3,710,851	1,901,089	31,988,420	45,014,678	12,147,255	175 107	5,605,097	12,264,066

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[1] Includes sales and head offices.
nes Not elsewhere specified.

TABLE 33. CANADA, PRINCIPAL STATISTICS OF THE MINERAL INDUSTRY[1] BY REGION, 1984

		Mines, Quarries and Oil Well Activity							Total Activity[2]		
		Production and Related Workers			Costs						
	Establishments	Employees	Person-hours Paid	Wages	Fuel and Electricity	Materials and Supplies	Value of Production	Value Added	Employees	Salaries and Wages	Value Added
	(number)	(number)	(000)	($000)	($000)	($000)	($000)	($000)	(number)	($000)	($000)
Atlantic[3]	104	7 553	15 597	216,530	161,413	519,010	1,525,961	864,710	9 879	297,168	879,888
Quebec	183	12 997	25 996	369,595	197,809	661,950	1,686,135	884,377	16 428	512,961	890,569
Ontario	139	19 816	38 452	622,295	108,889	1,120,616	3,813,416	2,495,908	26 765	877,861	2,513,220
Prairies	699	18 888	38 129	617,852	426,871	1,130,958	27,354,506	25,796,676	48 291	1,778,752	25,861,162
British Columbia[4]	196	9 423	19 391	372,298	202,740	617,187	2,964,157	2,124,230	13 206	539,897	2,114,935
Yukon and Northwest Territories[5]	62	2 611	5 832	126,433	46,287	252,451	653,868	355,130	3 877	181,491	365,971
Canada	1,381	70 688	142 795	2,325,003	1,204,009	4,290,972	37,976,019	32,481,039	118 626	4,187,990	32,565,725

[1] Cement manufacturing, lime manufacturing, clay and clay products are included in the mineral manufacturing industry. [2] Total activity includes sales and head offices. [3] Includes eastern Canada offshore. [4] Includes western Canada offshore. [5] Includes Arctic Islands and offshore.

TABLE 34. CANADA, PRINCIPAL STATISTICS OF THE MINERAL MANUFACTURING INDUSTRY BY REGION, 1984

		Mineral Manufacturing Activity							Total Activity[1]		
		Production and Related Workers			Costs						
	Establishments	Employees	Person-hours Paid	Wages	Fuel and Electricity	Materials and Supplies	Value of Shipments	Value Added	Employees	Salaries and Wages	Value Added
	(number)	(number)	(000)	($000)	($000)	($000)	($000)	($000)	(number)	($000)	($000)
Atlantic Provinces	163	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Quebec	530	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Ontario	876	71 015	152 961	2,132,906	910,567	13,997,912	20,961,509	6,117,116	90 590	1,170,611	6,175,480
Prairie Provinces	503	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
British Columbia	249	8 692	18 161	270,563	92,707	2,550,522	3,526,030	963,177	12 247	906,775	977,245
Yukon and Northwest Territories	1	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Canada	2 102	126 147	262 222	3,730,051	1,901,009	31,908,620	65,014,670	12,147,251	175 107	5,605,196	12,264,066

[1] Includes sales and head offices. (2) Confidential, included in Canadian total.

TABLE 35. CANADA, PRINCIPAL STATISTICS OF THE MINERAL INDUSTRY[1], 1978-84

	Mineral Manufacturing Activity								Total Activity[2]		
		Production and Related Workers			Costs						
	Establishments	Employees	Person-hours Paid	Wages	Fuel and Electricity	Materials and Supplies	Value of Production	Value Added	Employees	Salaries and Wages	Value Added
	(number)	(number)	(000)	($000)	($000)	($000)	($000)	($000)	(number)	($000)	($000)
1978	1 178	70 306	150 291	1,275,008	506,119	2,766,072	18,201,459	14,929,268	109 948	2,118,342	15,011,430
1979	1 150	72 580	152 560	1,493,773	605,985	3,252,991	23,626,730	19,767,754	115 245	2,492,715	19,894,086
1980	1 322	80 066	166 427	1,779,388	706,406	3,802,062	27,566,272	23,057,804	126 422	2,979,470	23,252,708
1981	1 361	81 136	167 307	2,053,760	888,554	4,266,637	28,204,485	23,049,295	129 251	3,439,965	23,091,447
1982	1 249	74 958	142 626	2,025,895	956,296	3,768,771	29,101,618	24,376,549	123 486	3,648,004	24,442,997
1983	1 407	66 629	131 406	1,963,773	1,022,417	3,756,625	32,771,401	27,992,357	113 831	3,687,912	28,012,167
1984	1 381	70 688	142 795	2,325,003	1,204,009	4,290,972	37,976,019	32,481,039	118 426	4,187,990	32,545,725

[1] Cement manufacturing, lime manufacturing, clay and clay products (domestic clays) are included in the mineral manufacturing industries. [2] Includes sales and head offices.

TABLE 36. CANADA, PRINCIPAL STATISTICS OF THE MINERAL MANUFACTURING INDUSTRIES, 1978-84

	Mineral Manufacturing Activity								Total Activity[2]		
		Production and Related Workers			Costs						
	Establishments	Employees	Person-hours Paid	Wages	Fuel and Electricity	Materials and Supplies	Value of Production	Value Added	Employees	Salaries and Wages	Value Added
	(number)	(number)	(000)	($000)	($000)	($000)	($000)	($000)	(number)	($000)	($000)
1978	2 022	143 917	297 554	2,365,782	981,506	15,700,614	24,036,539	7,272,298	198 085	3,494,336	7,421,897
1979	2 115	145 929	308 770	2,614,816	1,118,146	19,116,369	28,318,690	8,522,128	202 695	3,910,454	8,669,240
1980	2 143	146 606	308 312	2,927,363	1,272,902	27,045,572	32,177,335	9,417,966	204 872	4,386,065	9,599,868
1981	2 124	140 914	293 781	3,187,786	1,560,453	28,125,138	39,495,229	10,862,006	203 051	4,932,893	11,062,937
1982	2 106	124 304	256 900	3,175,123	1,537,247	27,801,486	38,496,873	9,078,253	182 665	5,070,760	9,256,207
1983	2 143	119 093	246 101	3,281,473	1,701,521	29,177,081	41,675,029	10,580,670	171 719	5,128,268	10,759,467
1984	2 182	124 147	262 222	3,710,851	1,901,089	31,588,420	45,014,678	12,147,253	175 107	5,605,097	12,264,066

[1] Includes sales and head offices.

TABLE 37. CANADA, CONSUMPTION OF FUEL AND ELECTRICITY IN THE MINERAL INDUSTRY[1], 1984

	Unit	Metals	Industrials[2]	Fuels	Total
Coal	000 t	131	-	-	131
	$000	5,835	-	-	5,835
Gasoline	000 litres	22 888	14 222	13 138	50 248
	$000	9,678	6,091	4,580	20,349
Fuel oil, kerosene, diesel oil	000 litres	939 262	231 359	199 667	1 370 288
	$000	265,186	71,575	62,709	399,470
Liquefied petroleum gas	000 litres	103 751	7 350	20 692	131 793
	$000	22,116	1,995	3,920	28,031
Natural gas	000 m^3	146 466	794 613	153 000	1 094 079
	$000	22,133	89,825	18,028	129,986
Other fuels[3]	$000	6,289	-	-	6,289
Total value of fuels	$000	331,237	169,486	89,237	589,960
Electricity purchased	million kWh	11 672	2 120	5 840	19 632
	$000	272,932	76,884	264,233	614,049
Total value of fuels and electricity purchased, all reporting companies	$000	604,169	246,370	353,470	1,024,009

Note: Totals may not add due to rounding.

[1] Cement and lime manufacturing and manufacturers of clay products (domestic clays) are included under mineral manufacturing. [2] Includes structural materials. [3] Includes wood, manufactured gas, steam purchased and other miscellaneous fuels.

- Nil.

TABLE 38. CANADA, CONSUMPTION OF FUEL AND ELECTRICITY IN THE MINERAL MANUFACTURING INDUSTRIES, 1984

	Unit	Primary Metal Industries	Nonmetallic Mineral Products Industries	Petroleum and Coal Products Industries	Total
Coal and coke	000 t	340	711	-	1 052
	$000	37,572	42,202	-	79,774
Gasoline	000 litres	12 248	22 836	2 594	37 678
	$000	5,056	9,929	1,069	16,054
Fuel oil, kerosene, diesel oil	000 litres	728 127	297 801	11 351	1 037 279
	$000	169,929	83,982	3,175	257,086
Liquefied petroleum gas	000 litres	49 988	15 398	15 286	80 672
	$000	11,310	3,564	3,465	18,339
Natural gas	000 m^3	2 490 900	1 435 900	1 499 400	5 426 200
	$000	365,560	207,148	205,112	777,820
Other fuels	$000	15,750	21,391	8,548	45,689
Total value of fuels	$000	605,177	368,216	221,369	1,194,762
Electricity purchased	million kWh	18 904	4 439	3 517	26 860
	$000	463,357	143,243	99,727	706,327
Total value of fuels and electricity purchased, all reporting companies	$000	1,068,535	511,459	321,095	1,901,089

Note: Totals may not add due to rounding.
- Nil.

TABLE 39. CANADA, COST OF FUEL AND ELECTRICITY USED IN THE MINING INDUSTRY[1], 1978-84

	Unit	1978	1979	1980	1981	1982	1983	1984
Metals								
Fuel	$000	153,608	193,828	220,052	293,979	275,205	270,098	331,231
Electricity purchased	million kWh	10 739	11 459	11 024	10 494	9 891	9 659	11 672
	$000	132,100	153,905	174,837	209,316	232,137	238,458	272,932
Total cost of fuel and electricity	$000	285,708	347,733	394,889	503,295	507,942	508,556	604,169
Industrials[2]								
Fuel	$000	79,090	92,499	112,672	142,169	143,393	157,872	169,486
Electricity purchased	million kWh	2 082	2 244	2 269	2 100	1 782	1 928	2 120
	$000	35,141	42,982	48,336	56,297	57,567	64,052	76,884
Total cost of fuel and electricity	$000	114,231	135,481	161,008	198,466	200,960	221,924	246,370
Fuels								
Fuels	$000	19,774	23,988	32,582	46,991	70,484	68,800	89,237
Electricity purchased	million kWh	2 699	3 238	3 504	3 740	5 780	4 958	5 840
	$000	81,624	98,783	117,927	139,802	176,911	223,136	264,233
Total cost of fuel and electricity	$000	101,398	122,771	150,509	186,793	247,395	291,936	353,470
Total mining industry								
Fuel	$000	252,470	310,315	365,306	483,139	489,683	496,770	589,960
Electricity purchased	million kWh	15 520	16 941	16 797	16 334	17 453	16 546	19 632
	$000	248,865	295,670	341,100	405,415	466,614	525,646	614,049
Total cost of fuel and electricity	$000	501,335	605,985	706,406	888,554	956,297	1,022,416	1,204,009

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[1] Cement and lime manufacturing and manufacturers of clay products (domestic clays) are included in mineral manufacturing.
[2] Includes structural materials.

TABLE 40. CANADA, COST OF FUEL AND ELECTRICITY USED IN THE MINERAL MANUFACTURING INDUSTRIES, 1978-84

	Unit	1978	1979	1980	1981	1982	1983	1984
Primary metals								
Fuel	$000	336,684	357,775	421,426	538,175	526,073	555,381	605,177
Electricity purchased	million kWh	17 257	18 451	20 535	20 429	16 848	17 524	18 904
	$000	226,313	260,317	316,884	357,186	345,614	396,632	463,357
Total cost of fuel and electricity	$000	562,997	618,092	738,317	895,361	871,687	952,014	1,068,535
Nonmetallic mineral products								
Fuel	$000	221,855	280,846	271,481	333,061	328,566	342,315	368,216
Electricity purchased	million kWh	4 782	5 163	4 633	4 573	3 973	3 983	4 439
	$000	79,606	98,296	102,765	114,062	116,243	125,310	143,243
Total cost of fuel and electricity	$000	301,461	379,142	374,248	447,123	444,809	467,624	511,459
Petroleum and coal products								
Fuels	$000	61,891	74,968	88,311	137,463	134,303	187,624	221,369
Electricity purchased	million kWh	3 505	3 555	3 705	3 669	3,476	3 491	3 517
	$000	55,303	63,395	72,186	80,517	86,448	94,259	99,727
Total cost of fuel and electricity	$000	117,194	138,363	160,498	217,980	220,751	281,883	321,095
Total mineral manufacturing industries								
Fuel	$000	620,430	713,589	781,218	1,008,699	988,942	1,085,391	1,194,762
Electricity purchased	million kWh	25 544	27 169	28 873	28 671	24 297	24 997	26 860
	$000	361,222	422,008	491,834	551,765	548,305	616,201	706,327
Total cost of fuel and electricity	$000	981,652	1,135,597	1,273,063	1,560,464	1,537,247	1,701,521	1,901,089

TABLE 41. CANADA, EMPLOYMENT, SALARIES AND WAGES IN THE MINING INDUSTRY[1], 1978-84

	Unit	1978	1979	1980	1981	1982	1983	1984
Metals								
Production and related workers	Number	39 977	41 541	47 592	49 586	44 261	37 270	39 181
Salaries and wages	$000	757,258	879,383	1,091,848	1,265,547	1,180,485	1,110,308	1,296,157
Annual average salary and wage	$	18,942	21,169	22,942	25,522	26,671	29,791	33,081
Administrative and office workers	Number	16 470	17 419	18 526	19 126	17 242	14 924	13 502
Salaries and wages	$000	358,680	428,639	504,316	585,120	585,249	533,517	518,644
Annual average salary and wage	$	21,778	24,608	27,222	30,593	33,943	35,749	38,412
Total metals								
Employees	Number	56 447	58 960	66 118	68 712	61 503	52 194	52 683
Salaries and wages	$000	1,115,938	1,308,022	1,596,165	1,850,667	1,765,734	1,643,825	1,814,801
Annual average salary and wage	$	19,770	22,185	24,141	26,933	28,710	31,495	34,447
Industrials								
Production and related workers	Number	16 133	16 633	16 645	15 666	12 848	12 768	13 008
Salaries and wages	$000	274,037	321,303	343,004	352,302	309,736	329,199	356,828
Annual average salary and wage	$	16,986	19,317	20,607	22,488	24,108	25,783	27,431
Administrative and office workers	Number	4 749	4 829	4 795	4 908	4 323	3 805	4 250
Salaries and wages	$000	95,659	106,776	116,932	128,852	129,116	114,656	138,012
Annual average salary and wage	$	20,143	22,114	24,386	26,253	29,867	30,133	32,473
Total industrials								
Employees	Number	20 882	21 462	21 440	20 574	17 171	16 573	17 258
Salaries and wages	$000	369,696	428,079	459,936	481,154	438,852	443,855	494,840
Annual average salary and wage	$	17,704	19,946	21,452	23,387	25,558	26,782	28,673
Fuels								
Production and related workers	Number	14 196	14 406	15 829	15 884	17 849	16 591	18 499
Salaries and wages	$000	243,713	293,087	344,537	435,911	535,673	524,264	672,018
Annual average salary and wage	$	17,168	20,345	21,766	27,443	30,011	31,599	35,025
Administrative and office workers	Number	18 423	20 417	23 035	24 081	26 963	28 473	29 986
Salaries and wages	$000	388,995	463,527	578,832	672,213	907,745	1,075,246	1,206,331
Annual average salary and wage	$	21,115	22,703	25,128	27,915	33,666	37,764	40,230
Total fuels								
Employees	Number	32 619	34 823	38 864	39 965	44 812	45 064	48 485
Salaries and wages	$000	632,708	756,614	923,369	1,108,124	1,443,418	1,599,510	1,878,349
Average annual salary and wage	$	19,397	21,727	23,759	27,727	32,211	35,494	38 741
Total mining								
Production and related workers	Number	70 306	72 580	80 066	81 136	74 958	66 629	70 688
Salaries and wages	$000	1,275,008	1,493,773	1,779,388	2,053,760	2,025,895	1,963,773	2,325,003
Average annual salary and wage	$	18,135	20,581	22,224	25,313	27,027	29,473	32,891
Administrative and office workers	Number	39 642	42 665	46 356	48 115	48 528	47 202	47 738
Salaries and wages	$000	843,335	998,942	1,200,081	1,386,184	1,622,110	1,724,139	1,862,987
Annual average salary and wage	$	21,274	23,414	25,888	28,810	33,426	36,527	39,025
Total mining								
Employees	Number	109 948	115 245	126 422	129 251	123 486	113 831	118 426
Salaries and wages	$000	2,118,343	2,492,715	2,979,470	3,439,945	3,648,004	3,687,912	4,187,990
Annual average salary and wage	$	19,267	21,630	23,568	26,614	29,542	32,398	35,364

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[1] Does not include cement and lime manufacturing and clay products (domestic clays) manufacturing.

TABLE 42. CANADA, EMPLOYMENT, SALARIES AND WAGES IN THE MINERAL MANUFACTURING INDUSTRIES, 1978-84

	Unit	1978	1979	1980	1981	1982	1983	1984
Primary metal industries								
Production and related workers	Number	93 798	95 942	97 530	92 337	82 186	77 579	81 454
Salaries and wages	$000	1,544,412	1,725,904	1,980,423	2,120,019	2,157,186	2,216,614	2,564,420
Annual average salary and wage	$	16,465	17,989	20,306	22,960	26,248	28,572	31,483
Administrative and office workers	Number	28 198	30 812	28 920	32 831	31 029	27 773	27 496
Salaries and wages	$000	597,544	713,279	787,022	938,790	1,010,847	964,429	1,033,620
Annual average salary and wage	$	21,191	23,149	27,214	28,595	32,577	34,725	37,592
Total primary metal industries								
Employees	Number	121 996	126 754	126 450	125 168	113 215	105 352	108 950
Salaries and wages	$000	2,140,956	2,432,183	2,767,445	3,058,809	3,168,033	3,181,043	3,598,040
Annual average salary and wage	$	17,549	19,188	21,886	24,438	27,982	30,194	33,025
Nonmetallic mineral products industries								
Production and related workers	Number	41 297	41 813	40 799	40 145	33 997	34 097	36 155
Salaries and wages	$000	638,152	710,622	743,254	818,566	751,915	800,755	883,604
Annual average salary and wage	$	15,452	16,995	18,217	20,390	22,117	23,485	24.439
Administrative and office workers	Number	14 439	14 935	15 287	15 124	13 952	13 353	12 738
Salaries and wages	$000	264,166	297,211	333,815	369,899	383,405	391,901	394,619
Annual average salary and wage	$	18,295	19,900	21,837	24,458	27,480	29,349	30,980
Total nonmetallic mineral products								
Employees	Number	55 736	56 748	56 086	55 269	47 949	47 450	48 893
Salaries and wages	$000	902,318	1,007,833	1,077,069	1,188,455	1,135,320	1,192,656	1,278,223
Annual average salary and wage	$	16,189	17,760	19,203	21,503	23,678	25,135	26,143
Petroleum and coal products industries								
Production and related workers	Number	8 822	8 174	8 277	8 432	8 121	7 417	6 538
Salaries and wages	$000	183,218	185,290	203,686	249,199	266,022	264,104	262,827
Annual average salary and wage	$	20,768	22,668	24,609	29,554	32,757	35,608	40,200
Administrative and office workers	Number	11 531	11 019	11 769	14 182	13 380	11 500	10 726
Salaries and wages	$000	267,844	285,148	337,865	436,430	501,385	490,465	466,006
Annual average salary and wage	$	23,228	25,887	28,708	30,773	37,473	42,649	43,446
Total petroleum and coal products								
Employees	Number	20 353	19 193	20 046	22 614	21 501	18 917	17 264
Salaries and wages	$000	451,062	470,438	541,551	685,629	767,407	754,569	728,833
Annual average salary and wage	$	22,162	24,511	27,015	30,319	35,692	39,888	42,217
Total mineral manufacturing								
Production and related workers	Number	143 917	145 929	146 606	140 914	124 304	119 093	124 147
Salaries and wages	$000	2,365,782	2,621,816	2,927,363	3,187,784	3,175,123	3,281,473	3,710,851
Annual average salary and wage	$	16,439	17,966	19,968	22,622	25,543	27,554	29,891
Administrative and office workers	Number	54 168	56 766	55 976	62 137	58 359	52 626	50 960
Salaries and wages	$000	1,129,554	1,295,638	1,458,702	1,745,109	1,895,637	1,846,795	1,894,246
Annual average salary and wage	$	20,853	22,824	26,059	28,085	32,482	35,093	37,171
Total mineral manufacturing industries								
Employees	Number	198 085	202 695	202 582	203 051	182 665	171 719	175 107
Salaries and wages	$000	3,494,336	3,910,454	4,386,065	4,932,893	5,070,760	5,128,268	5,605,097
Annual average salary and wage	$	17,641	19,292	21,651	24,296	27,760	29,864	32,010

TABLE 43. CANADA, NUMBER OF WAGE EARNERS EMPLOYED IN THE MINING INDUSTRY (SURFACE, UNDERGROUND AND MILL), 1978-84

	1978	1979	1980	1981	1982	1983	1984
Metals							
Surface	12 901	12 664	14 347	14 043	12 133	9 970	9 724
Underground	15 682	15 906	19 308	19 784	18 673	15 861	16 668
Mill	11 394	12 971	13 937	15 759	13 455	11 439	12 789
Total	39 977	41 541	47 592	49 586	44 261	37 270	39 181
Industrials							
Surface	6 660	6 877	6 510	6 015	4 833	4 951	4 948
Underground	2 275	2 370	2 550	2 606	2 055	2 192	2 487
Mill	7 198	7 386	7 585	7 045	5 960	5 625	5 573
Total	16 133	16 633	16 645	15 666	12 848	12 768	13 008
Fuels							
Surface	9 153	9 500	10 550	11 429	12 786	12 190	15 430
Underground	3 151	2 871	2 900	2 926	3 226	2 896	1 818
Mill	1 892	2 035	2 379	1 529	1 837	1 505	1 251
Total	14 196	14 406	15 829	15 884	17 849	16 591	18 499
Total mining industry							
Surface	28 714	29 041	31 407	31 487	29 752	27 111	30 102
Underground	21 108	21 147	24 758	25 316	23 954	20 949	20 973
Mill	20 484	22 392	23 901	24 333	21 252	18 569	19 613
Total	70 306	72 580	80 066	81 136	74 958	66 629	70 688

TABLE 44. CANADA, MINE AND MILL WORKERS BY SEX, 1984

	Mine workers							
	Underground		Surface		Mill workers		Total	
	Male	Female	Male	Female	Male	Female	Male	Female
Metallic minerals								
Nickel-copper-zinc	9 063	8	4 400	104	3 979	156	17 442	268
Gold	3 624	3	1 130	43	1 947	26	6 701	72
Iron ore	120	1	1 422	13	4 018	120	5 560	134
Uranium	2 157	8	1 680	40	753	78	4 590	126
Silver-lead-zinc	1 526	7	487	37	1 464	54	3 477	98
Miscellaneous metal mines	151	-	354	14	193	1	698	15
Total	16 641	27	9 473	251	12 354	435	38 468	713
Industrial minerals								
Asbestos	297	-	952	3	1 983	63	3 232	66
Potash	1 543	21	77	1	1 534	35	3 154	57
Miscellaneous nonmetals	481	-	409	7	1 105	28	1 995	35
Stone	3	-	1 529	5	195	2	1 727	7
Peat	-	-	611	24	488	10	1 099	34
Sand and gravel	-	-	882	7	60	-	942	7
Gypsum	142	-	441	-	70	-	653	-
Total	2 466	21	4 901	47	5 435	138	12 802	206
Fuels								
Coal	1 818	-	5 548	94	1 205	46	8 571	140
Mining Total	20 925	48	19 922	392	18 994	619	59 841	1 059

- Nil.

TABLE 45. CANADA, LABOUR COSTS FOR METAL MINES IN RELATION TO TONNES MINED, 1982-84

Type of Metal Mine	Number of Wage Earners	Total Wages	Average Annual Wage	Tonnage of Ore Mined	Average Annual Tonnes Mined per Wage Earner	Wage Cost per Tonne Mined
		($000)	($)	(kilotonnes)		($)
1982						
Uranium	3 596	124,024	34,489	7 609	2 116	16.30
Gold	4 440	125,178	28,193	8 368	1 885	14.96
Silver-lead-zinc	3 320	106,834	32,179	14 113	4 251	7.57
Miscellaneous metals	871	25,987	29,836	8 477	9 732	3.07
Nickel-copper-zinc	16 307	365,743	22,429	117 833	7 226	3.10
Iron ore	2 272	66,205	29,139	81 963	36 075	0.81
Total	30 806	813,971	26,422	238 362	7 738	3.41
1983						
Uranium	3 302	117,056	35,450	7 073	2 142	16.55
Gold	4 403	136,370	30,971	9 553	2 170	14.27
Silver-lead-zinc	2 157	76,949	35,674	9 157	4 245	8.40
Miscellaneous metals	320	10,959	34,248	2 133	6 665	5.14
Nickel-copper-zinc	14 133	374,211	26,478	116 532	8 245	3.21
Iron ore	1 516	50,509	33,317	74 597	49 206	0.68
Total	25 831	766,053	29,656	219 045	8 480	3.50
1984						
Uranium	3 885	139,466	35,889	7 608	1 958	18.33
Gold	4 800	161,233	33,590	11 225	2 339	14.36
Silver-lead-zinc	2 057	81,269	39,509	10 084	4 902	8.06
Miscellaneous metals	519	17,088	32,925	3 627	6 989	4.71
Nickel-copper-zinc	13 575	425,836	31,369	124 683	9 185	3.41
Iron ore	1 556	56,874	36,552	89 210	57 333	0.64
Total	26 392	881,766	33,410	246 437	9 338	3.58

TABLE 46. CANADA, PERSON-HOURS PAID FOR PRODUCTION AND RELATED WORKERS, AND TONNES OF ORE MINED AND ROCK QUARRIED IN METAL MINES AND OTHER MINERAL OPERATIONS, 1978-84

	Unit	1978	1979	1980	1981	1982	1983	1984
Metal mines[1]								
Ore mined	million t	248.1	274.8	290.1	301.5	238.4	219.0	246.4
Person-hours paid[2]	million	84.9	85.1	97.5	100.6	80.4	71.8	78.2
Person-hours paid per tonne mined	number	0.34	0.31	0.34	0.33	0.34	0.33	0.32
Tonnes mined per person-hour paid	t	2.92	3.23	2.98	3.00	2.97	3.05	3.15
Other mineral operations[3]								
Ore mined and rock quarried	million t	98.3	105.1	106.6	110.5	93.2	101.6	132.3
Person-hours paid[2]	million	38.8	40.4	41.4	38.6	34.8	32.2	34.0
Person-hours paid per tonne mined	number	0.40	0.38	0.39	0.35	0.37	0.31	0.26
Tonnes mined per person-hour paid	t	2.53	2.60	2.58	2.86	2.68	3.15	3.89

[1] Excludes placer mining. [2] Person-hours paid for production and related workers only.
[3] Includes asbestos, potash, gypsum and coal.

TABLE 47. CANADA, AVERAGE WEEKLY WAGES AND HOURS WORKED (INCLUDING OVERTIME) FOR HOURLY-RATED EMPLOYEES IN MINING, MANUFACTURING AND CONSTRUCTION INDUSTRIES, 1979-85

	1979	1980	1981	1982	1983[1]	1984	1985
Mining							
Average hours per week	41.1	40.8	40.4	39.6	38.8	39.3	39.7
Average weekly wage ($)	396.58	449.61	494.62	551.68	552.79	664.57	698.23
Metals							
Average hours per week	40.4	40.1	40.2	39.0	38.3	38.8	39.1
Average weekly wage ($)	387.14	425.08	485.03	535.92	565.60	610.91	639.92
Mineral fuels							
Average hours per week	40.8	41.2	41.3	42.1	39.7	40.6	41.1
Average weekly wage ($)	410.38	476.30	553.71	631.91	626.12	672.85	716.33
Nonmetals							
Average hours per week	40.3	39.5	38.7	37.2	37.5	38.7	39.2
Average weekly wage ($)	366.03	402.98	445.02	479.44	468.05	536.93	555.33
Manufacturing							
Average hours per week	38.8	38.5	38.5	37.7	38.4	38.5	38.9
Average weekly wage ($)	287.82	314.80	352.08	384.79	504.76	465.64	488.47
Construction							
Average hours per week	39.4	39.0	38.9	38.1	36.9	37.2	37.7
Average weekly wage ($)	433.51	470.45	531.54	564.33	512.26	490.95	504.85

[1] Ten-month average; new time series.

TABLE 48. CANADA, AVERAGE WEEKLY WAGES (INCLUDING OVERTIME) OF HOURLY-RATED EMPLOYEES IN THE MINING INDUSTRY, IN CURRENT AND 1971 DOLLARS, 1979-85

	1979	1980	1981	1982	1983[1]	1984	1985
Current dollars							
All mining	396.58	440.61	494.62	551.68	552.79	664.57	698.23
Metals	387.14	425.08	485.03	535.92	565.60	610.91	639.92
Mineral fuels	414.96	476.30	553.11	631.91	626.12	672.85	716.33
Coal	362.20	430.16	485.03	562.12	564.18	653.52	697.48
Nonmetals except fuel	330.47	402.98	445.02	479.44	504.76	536.93	555.33
1971 dollars							
All mining	207.42	209.22	208.79	210.16	199.04	229.32	226.92
Metals	202.48	226.16	244.74	204.16	203.65	210.80	207.97
Mineral fuels	217.03	220.82	233.48	240.73	225.44	232.18	232.80
Coal	189.44	204.25	204.74	214.14	203.14	225.51	226.68
Industrial minerals	172.84	191.35	187.85	182.64	181.76	185.28	180.48

[1] Ten-month average; new time series.

TABLE 49. CANADA, INDUSTRIAL FATALITIES PER THOUSAND WORKERS[1] BY INDUSTRY GROUPS, 1983-85

	Fatalities (number)[1]			Number of Workers (000)			Rate per 1,000 Workers[2]		
	1983	1984	1985P	1983	1984	1985P	1983	1984	1985P
Agriculture	21	20	20	156.0	156.0	168.0	0.13	0.13	0.12
Forestry	61	60	65	55.2	56.9	55.0	1.11	1.05	1.18
Fishing[3]	15	27	26	15.0	14.0	12.0	1.00	1.93	2.17
Mining[4]	100	102	116	146.6	149.1	156.6	0.68	0.68	0.74
Manufacturing	145	122	115	1 712.2	1 670.9	1 703.9	0.08	0.07	0.07
Construction	116	145	122	350.9	346.3	384.3	0.33	0.42	0.32
Transportation[5]	137	123	122	789.7	800.2	804.5	0.17	0.15	0.15
Trade	58	52	71	1 490.7	1 581.5	1 621.3	0.04	0.03	0.04
Finance[6]	4	10	4	520.0	539.5	556.6	0.01	0.02	0.01
Service[7]	73	62	42	2 876.2	2 927.3	3 085.0	0.03	0.02	0.01
Public administration	54	65	46	655.0	658.7	661.9	0.08	0.10	0.07
Unknown	10	11	19	..	..	..	..	..	..
Total	794	799	768	8 767.5	8 900.4	9 209.1	0.09	0.09	0.08

[1] Includes fatalities resulting from occupational chest illnesses such as silicosis, lung cancer, etc. [2] The rates may be understated because only 80 per cent of workers in the Statistics Canada employment estimates are covered by workers' compensation. [3] Includes trapping and hunting. [4] Includes quarrying and oil wells. [5] Includes storage, communication, electric power and water utilities and highway maintenance. [6] Includes insurance and real estate. [7] Includes community, business and personnel service.

P Preliminary; .. Not available.

TABLE 50. CANADA, INDUSTRIAL FATALITIES PER THOUSAND WORKERS BY INDUSTRY GROUPS, 1979-85[1]

	1979	1980	1981	1982	1983	1984	1985P[2]
Agriculture	0.11	0.05	0.14	0.13	0.13	0.13	0.12
Forestry	1.55	1.14	0.95	1.22	1.11	1.05	1.18
Fishing[3]	1.25	1.60	1.47	1.58	1.00	1.93	2.17
Mining[4]	0.97	1.08	0.76	0.96	0.68	0.68	0.74
Manufacturing	0.09	0.09	0.09	0.11	0.08	0.07	0.07
Construction	0.40	0.42	0.39	0.35	0.33	0.42	0.32
Transportation[5]	0.26	0.27	0.25	0.22	0.17	0.15	0.15
Trade	0.05	0.05	0.04	0.04	0.04	0.02	0.04
Finance[6]	0.01	0.01	0.02	0.01	0.01	0.02	0.01
Service[7]	0.03	0.03	0.03	0.03	0.03	0.03	0.01
Public administration	0.11	0.07	0.11	0.08	0.08	0.10	0.07
Total	0.12	0.13	0.11	0.11	0.09	0.09	0.08

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[1] Includes fatalities resulting from occupational chest illnesses such as silicosis, lung cancer, etc. [2] The rates may be understated because only 80 per cent of workers in the Statistics Canada employment estimates are covered by workers' compensation. [3] Includes trapping and hunting. [4] Includes quarrying and oil wells. [5] Includes storage, communication, electric power and water utilities and highway maintenance. [6] Includes insurance and real estate. [7] Includes community, business and personnel service.

P Preliminary.

TABLE 51. CANADA, INDUSTRIAL FATALITIES BY OCCUPATIONAL INJURIES AND ILLNESSES[1], 1983-85

	Occupational Injuries			Occupational Illnesses[2]			Total		
	1983	1984	1985P	1983	1984	1985P	1983	1984	1985P
Agriculture	12	15	16	0	0	0	12	15	16
Forestry	54	56	58	0	0	1	54	56	59
Fishing	15	27	22	0	0	0	15	27	22
Mining	40	47	66	54	48	45	94	95	111
Manufacturing	83	78	75	36	33	24	119	111	99
Construction	79	98	84	16	18	22	95	116	106
Transportation	112	96	104	3	8	4	115	104	108
Trade	43	36	57	1	2	3	44	38	60
Finance	2	5	3	0	0	0	2	5	3
Service	52	49	27	2	0	2	54	49	29
Public administration	39	42	30	2	5	2	41	47	32
Unknown	0	1	2	0	0	1	0	1	3
Total	531	550	544	114	114	104	645	664	648

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[1] Excludes the Province of Quebec for which data is unavailable. [2] Includes fatalities resulting from occupational chest illnesses such as silicosis, lung cancer, etc.

P Preliminary.

TABLE 52. CANADA, NUMBER OF STRIKES AND LOCKOUTS BY INDUSTRIES, 1983-85

	1983			1984			1985P		
	Strikes and Lockouts	Workers Involved	Duration in Person-days	Strikes and Lockouts	Workers Involved	Duration in Person-days	Strikes and Lockouts	Workers Involved	Duration in Person-days
Agriculture	2	26	770	2	123	190	1	16	290
Forestry	5	1 326	13 890	9	952	9 580	8	1 409	8 120
Fishing and trapping	1	3 000	3 000	0	0	0	0	0	0
Mines	12	11 889	178 390	9	2 029	37 120	12	6 309	90 180
Manufacturing	311	64 206	1 385 290	343	107 973	2 373 170	356	66 075	1 578 010
Construction	24	9 394	243 680	36	19 500	212 700	14	992	11 210
Transportation and utilities	63	15 257	275 000	48	20 091	550 340	96	38 763	478 900
Trade	74	14 831	251 690	101	5 721	188 220	129	23 196	467 880
Finance, insurance and real estate	17	606	9 600	23	559	26 230	18	1 337	106 920
Service	104	168 376	1 770 710	112	26 417	415 660	160	15 631	383 900
Public administration	32	40 398	311 940	34	3 390	70 190	31	5 999	55 300
Various industries	0	0	0	0	0	0	0	0	0
All industries	645	329 309	4 443 960	717	186 755	3 883 400	825	159 727	3 180 710

P Preliminary.

TABLE 53. CANADA, NUMBER OF STRIKES AND LOCKOUTS BY MINING AND MINERAL MANUFACTURING INDUSTRIES, 1983-85

	1983			1984			1985P		
	Strikes and Lockouts	Workers Involved	Duration in Person-days	Strikes and Lockouts	Workers Involved	Duration in Person-days	Strikes and Lockouts	Workers Involved	Duration in Person-days
Mines	12	11 889	178 390	9	2 029	37 120	12	6 309	90 180
Metals	6	6 046	91 500	6	1 755	36 240	5	4 018	40 760
Mineral fuels	3	4 991	80 950	0	0	0	2	1 400	13 030
Nonmetals	2	847	5 543	2	261	570	3	835	35 850
Quarries	1	5	400	1	13	310	2	56	540
Mineral manufacturing	32	4 334	118 540	35	6 378	163 160	38	4 068	131 010
Primary metals	15	2 609	88 070	17	3 684	41 920	16	2 804	63 440
Nonmetallic mineral products	17	1 725	30 470	16	2 209	119 480	22	1 264	67 570
Petroleum and coal products	0	0	0	2	485	1 760	0	0	0

P Preliminary.

TABLE 54. CANADA, SOURCE OF ORES HOISTED OR REMOVED FROM SELECTED TYPES OF MINES, 1982-84

Mines	1982 Underground	1982 Open-pit	1982 Total	1983 Underground	1983 Open-pit	1983 Total	1984 Underground	1984 Open-pit	1984 Total
					(kilotonnes)				
Nickel-copper-zinc	21 431	96 402	117 833	25 078	91 454	116 532	29 916	94 766	124 683
Iron ore	2 448	79 515	81 963	2 803	71 794	74 597	1 796	87 414	89 210
Coal	5 254	47 725	52 979	5 259	49 558	54 817	4 777	66 430	71 207
Asbestos	1 308	16 184	17 492	1 511	13 524	15 035	1 691	14 035	15 725
Gold	6 710	1 657	8 367	7 497	2 056	9 553	8 293	2 932	11 225
Silver-lead-zinc	9 950	4 163	14 113	7 726	1 431	9 157	7 767	2 317	10 084
Gypsum	475	5 355	5 830	873	6 667	7 540	1 199	7 670	8 869
Uranium	6 900	709	7 609	6 259	814	7 073	7 002	606	7 608
Miscellaneous metals	1 517	6 959	8 476	528	1 605	2 133	1 582	2 045	3 627
Total	55 993	258 669	314 662	57 534	238 903	296 437	64 023	278 215	342 238
Percentage	17.8	82.2	100.0	19.4	80.6	100.0	18.7	81.3	100.0

TABLE 55. CANADA, SOURCE OF MATERIAL HOISTED OR REMOVED FROM METAL MINES, 1984

	Underground		Open-pit		
	Ore	Waste	Ore	Waste	Overburden
			(kilotonnes)		
Nickel-copper-zinc	29 916	2 796	94 766	91 193	54 033
Iron	1 796	43	87 414	26 945	14 219
Gold	8 293	1 228	2 932	14 266	1 195
Silver-lead-zinc	7 767	946	2 317	9 325	15 802
Uranium	7 002	387	606	3 733	2 834
Miscellaneous metals	1 582	59	2 045	1 134	9
Total	56 356	5 459	190 080	146 596	88 092

TABLE 56. CANADA, ORE MINED AND ROCK QUARRIED IN THE MINING INDUSTRY, 1978-84

	1978	1979	1980	1981	1982	1983	1984
				(kilotonnes)			
Metals							
Nickel-copper-zinc	109 613	109 437	121 399	137 709	117 833	116 532	124 683
Iron	96 323	130 799	123 107	118 579	81 963	74 597	89 210
Gold	5 914	5 478	6 346	6 810	8 368	9 553	11 225
Silver-lead-zinc	15 859	15 078	16 219	15 964	14 113	9 157	10 084
Uranium	6 126	6 141	7 152	7 454	7 608	7 073	7 608
Miscellaneous metals	14 221	7 822	15 871	15 014	8 477	2 133	3 627
Total	248 056	274 755	290 095	301 530	238 362	219 045	246 437
Nonmetals							
Potash	24 856	25 511	26 988	30 344	16 946	24 222	36 542
Asbestos	28 788	31 522	28 103	25 664	17 493	15 035	15 725
Gypsum	8 393	8 310	7 611	6 220	5 830	7 540	8 869
Rock salt	5 050	5 639	5 321	4 927	5 723	5 996	6 706
Total	67 087	70 982	68 023	67 155	45 992	52 793	67 842
Structural materials							
Stone, all kinds quarried[1]	122 144	109 719	103 366	86 860	59 181	67 651	81 754
Stone used to make cement	13 051	13 982	14 138	14 047	10 593	10 154	10 101
Stone used to make lime	3 178	3 028	4 751	1 626	3 411	3 446	4 260
Total	138 373	126 729	122 255	102 533	73 085	81 251	96 115
Fuels							
Coal	36 276	39 755	43 930	48 237	52 979	54 817	71 207
Total ore mined and rock quarried	489 792	512 221	524 303	519 455	410 418	407 906	481 601

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[1] Excludes stone used to manufacture cement and lime.

TABLE 57. CANADA, EXPLORATION AND CAPITAL EXPENDITURES IN THE MINING INDUSTRY[1] BY PROVINCES AND TERRITORIES, 1984-86

		Capital						Repair					
		Construction											
		On-property exploration	On-property development	Structures	Total	Machinery and equipment	Total capital	Construction	Machinery and equipment	Total repair	Total capital and repair	Outside or general exploration	Total, all expenditures
							($ million)						
Newfoundland	1984	0.5	x	x	x	x	29.9	x	x	104.5	134.4	9.2	143.6
	1985P	x	15.0	x	x	x	24.3	x	x	114.8	139.1	13.5	152.6
	1986¹	0.5	14.6	-	15.1	24.5	39.6	x	x	107.5	147.1	14.4	161.5
Prince Edward Island	1984	-	-	-	-	-	-	-	-	-	-	-	-
	1985P	-	-	-	-	-	-	-	-	-	-	-	-
	1986¹	-	-	-	-	-	-	-	-	-	-	-	-
Nova Scotia	1984	x	x	37.4	71.5	62.4	133.9	2.1	15.8	17.9	151.8	6.4	158.2
	1985P	x	x	x	x	x	245.2	0.6	19.0	19.6	264.8	9.2	274.0
	1986¹	x	x	x	x	x	138.5	1.9	28.4	30.3	168.8	9.2	178.0
New Brunswick	1984	x	32.6	x	x	x	190.1	x	x	56.4	246.5	9.8	256.3
	1985P	1.2	x	x	x	x	161.3	7.5	51.7	59.2	220.5	5.6	226.1
	1986¹	4.8	x	x	25.8	62.2	88.0	x	x	57.1	145.1	5.3	150.4
Quebec	1984	30.6	163.9	51.6	246.1	70.7	316.8	26.8	167.1	193.9	510.9	115.7	626.6
	1985P	30.0	160.9	76.1	267.0	64.7	331.7	20.8	205.4	226.2	557.9	122.2	680.1
	1986¹	28.2	160.1	56.2	244.5	68.3	312.8	22.9	199.5	222.4	535.2	123.0	658.2
Ontario	1984	34.1	234.3	95.0	363.4	161.8	525.2	48.4	327.3	375.7	900.9	117.6	1,018.5
	1985P	22.0	268.8	112.5	403.6	171.2	574.8	47.2	337.0	384.2	959.0	116.3	1,075.3
	1986¹	26.2	282.0	38.5	346.7	171.3	518.0	47.9	332.9	380.8	898.8	98.7	997.5
Manitoba	1984	x	31.7	x	48.1	15.6	63.7	5.6	42.2	47.8	111.5	18.6	130.1
	1985P	x	34.5	x	47.6	23.4	71.0	2.8	39.3	42.1	113.1	17.9	131.0
	1986¹	x	35.8	x	48.4	25.8	74.2	1.5	32.7	34.2	108.4	16.0	124.4
Saskatchewan	1984	12.0	22.3	60.4	94.7	162.9	257.6	17.4	134.0	151.4	409.0	32.3	441.3
	1985P	7.8	45.9	44.5	98.2	152.3	250.5	9.1	135.3	144.4	394.9	44.6	439.5
	1986¹	5.3	27.5	37.7	70.3	122.2	192.5	8.4	128.3	136.7	329.2	38.2	367.4
Alberta	1984	x	18.4	x	111.6	192.7	304.3	1.8	68.8	70.6	374.9	11.6	386.5
	1985P	x	7.0	x	15.3	37.1	52.4	5.7	68.4	74.1	126.5	10.5	137.0
	1986¹	x	11.7	x	18.8	22.8	41.6	6.7	62.7	69.4	111.0	11.8	122.8
British Columbia	1984	11.3	425.1	48.7	485.1	152.5	637.6	24.8	334.0	358.8	996.4	112.2	1,108.6
	1985P	7.5	111.9	134.1	253.5	82.2	335.7	18.4	340.3	358.7	694.4	98.1	792.5
	1986¹	7.1	82.2	57.7	147.1	108.1	255.2	19.1	367.3	386.4	641.6	89.9	731.5
Yukon	1984	x	x	x	x	x	6.9	0.3	12.2	12.5	19.4	15.9	35.3
	1985P	x	1.3	x	x	x	2.2	x	x	1.3	3.5	10.1	13.6
	1986¹	x	x	x	x	x	1.6	x	x	1.7	3.3	10.4	13.7
Northwest Territories	1984	18.1	32.5	6.7	57.3	21.9	79.2	7.9	65.3	73.2	152.4	31.6	184.0
	1985P	14.5	38.8	2.2	55.7	17.0	72.7	5.4	69.1	74.5	147.2	23.6	170.8
	1986¹	4.9	21.9	3.6	30.4	16.3	46.7	6.3	67.1	73.4	120.1	14.3	134.4
Canada	1984	136.4	1,007.7	456.8	1,600.9	944.4	2,545.3	146.8	1,315.8	1,462.6	4,007.9	480.9	4,488.8
	1985P	89.4	780.1	491.0	1,360.4	761.5	2,121.9	125.0	1,374.2	1,499.2	3,621.1	471.6	4,092.7
	1986¹	87.5	722.6	226.8	1,036.6	672.1	1,708.7	129.1	1,370.8	1,499.9	3,208.6	431.2	3,639.8

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[1] Excludes crude oil and natural gas industries.
P Preliminary; ¹ Intentions; x Confidential, included in total; - Nil.

TABLE 58. CANADA, EXPLORATION AND CAPITAL EXPENDITURES[1] IN THE MINING INDUSTRY BY TYPE OF MINING, 1984-86

		Capital						Repair					
		Construction											
		On-property exploration	On-property development	Structures	Total	Machinery and equipment	Total capital	Construction	Machinery and equipment	Total repair	Total capital and repair	Outside or general exploration	Total, all expenditures
							($ million)						
Metal Mines													
Gold	1984	58.8	174.4	121.0	354.2	147.5	501.7	18.1	80.4	98.5	600.2	59.8	560.0
	1985P	39.8	205.4	118.8	363.9	96.8	460.7	14.5	94.0	108.5	568.9	54.1	623.0
	1986i	34.7	210.5	46.1	291.2	88.0	379.2	18.6	100.2	118.8	498.0	50.3	548.3
Copper-gold-silver	1984	25.3	173.4	16.6	215.3	52.7	268.0	23.3	255.5	278.8	546.8	19.7	566.5
	1985P	11.2	47.3	96.2	154.7	74.7	229.4	14.3	198.1	212.4	441.8	20.9	462.7
	1986i	12.7	58.3	46.8	117.8	88.3	206.1	14.1	217.5	231.6	437.7	7.5	445.2
Silver-lead-zinc	1984	10.6	35.4	5.4	51.4	35.2	86.6	11.7	108.4	120.1	206.7	22.5	229.2
	1985P	9.1	44.8	9.7	63.6	21.2	84.8	11.6	85.1	96.7	181.5	13.3	194.8
	1986i	(4)	27.9	(4)	41.6	14.3	55.9	12.4	85.1	97.5	153.4	11.9	165.3
Iron	1984	(4)	76.5	(4)	82.3	8.2	90.5	8.5	179.4	187.9	278.4	(4)	(4)
	1985P	(4)	71.2	(4)	76.5	20.8	97.3	9.8	204.7	214.5	311.8	-	311.8
	1986i	(4)	71.1	(4)	76.0	37.7	113.7	9.7	192.5	202.2	315.9	-	315.9
Uranium	1984	(4)	89.3	(4)	114.8	71.4	186.2	6.1	110.6	116.7	302.9	(2)	(2)
	1985P	(4)	97.9	(4)	117.7	45.2	162.9	8.7	127.9	136.6	299.5	23.2	322.7
	1986i	(4)	93.0	(4)	103.9	45.5	149.4	8.3	130.3	138.6	288.0	17.2	305.2
Other metal[2] mining	1984	6.8	71.0	38.1	115.9	54.4	170.3	30.8	124.9	155.7	326.0	5.2	331.2
	1985P	7.4	92.1	38.0	137.3	126.0	263.3	28.6	127.0	155.6	418.9	2.2	421.1
	1986i	13.0	83.6	15.6	112.2	70.8	183.0	28.1	127.2	155.3	338.3	4.0	342.3
Total metal mining	1984	110.6	620.0	203.3	933.9	369.4	1,303.3	98.5	859.2	957.7	2,261.0	113.5	2,374.5
	1985P	76.2	558.7	279.1	913.3	384.7	1,298.4	87.2	836.8	924.0	2,222.4	113.7	2,336.1
	1986i	72.7	544.4	125.9	742.7	344.6	1,087.3	91.2	852.8	944.0	2,031.3	90.9	2,122.2
Nonmetal Mines													
Asbestos	1984	(4)	23.9	(4)	29.4	5.7	35.1	2.5	49.0	51.5	86.6	(4)	(4)
	1985P	(4)	(4)	(4)	22.3	6.5	28.8	(4)	(4)	54.7	83.5	(4)	(4)
	1986i	(4)	14.7	(4)	20.4	5.1	25.5	2.8	44.6	47.4	72.9	(4)	(4)
Coal	1984	17.8	337.1	138.3	493.2	338.6	831.8	26.4	202.9	229.3	1,061.1	21.1	1,082.2
	1985P	3.3	173.6	116.6	293.5	116.2	409.7	19.9	294.0	313.9	723.6	22.8	746.4
	1986i	4.9	140.1	57.0	202.0	111.8	313.8	21.5	291.6	313.1	626.9	28.6	655.5
Other non-metal mining[3]	1984	(4)	26.7	(4)	136.0	227.4	363.4	18.3	202.8	221.1	584.5	(4)	(4)
	1985P	(4)	(4)	(4)	122.1	251.0	373.1	(4)	(4)	202.9	576.0	(4)	(4)
	1986i	(4)	15.4	(4)	57.9	207.1	265.0	11.5	179.3	190.8	455.8	3.1	458.9
Total non-metal mining	1984	19.1	387.7	251.8	658.6	571.7	1,230.3	47.2	454.7	501.9	1,732.2	22.6	1,754.8
	1985P	7.5	(4)	(4)	437.9	373.7	811.6	(4)	(4)	571.5	1,383.1	24.9	1,408.0
	1986i	(4)	170.2	(4)	280.3	324.0	604.3	35.8	515.5	551.3	1,155.6	31.7	1,187.3
Metal and Nonmetal Exploration Companies	1984	6.7	-	1.7	8.4	3.3	11.7	1.1	1.9	3.0	14.7	344.8	359.5
	1985P	5.7	(4)	(4)	8.8	3.1	11.9	(4)	(4)	3.7	15.6	333.0	348.6
	1986i	(4)	8.0	(4)	13.6	3.5	17.1	2.1	2.5	4.6	21.7	308.6	330.3
Total mining	1984	136.4	1,007.7	456.8	1,600.9	944.4	2,545.3	146.8	1,315.8	1,462.6	4,007.9	480.9	4,488.8
	1985P	89.4	780.1	491.0	1,360.4	761.5	2,121.9	125.0	1,374.2	1,499.2	3,621.1	471.6	4,092.7
	1986i	87.5	722.6	226.8	1,036.6	672.1	1,708.7	129.1	1,370.8	1,499.9	3,208.6	431.2	3,639.8

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[1] Excludes expenditures in the petroleum and natural gas industries. [2] Includes nickel-copper mines, silver-cobalt mines and other metal mines. [3] Includes gypsum mines, salt mines, potash mines, quarries, sand and gravel pits and other nonmetal mines. (4) Confidential, included in total. P Preliminary; i Intentions; - Nil.

TABLE 59. CANADA, DIAMOND DRILLING IN THE MINING INDUSTRY BY MINING COMPANIES WITH OWN EQUIPMENT AND BY DRILLING CONTRALTORS, 1982-84

		1982			1983			1984		
		Exploration	Other	Total	Exploration	Other	Total	Exploration	Other	Total
						(metres)				
Metal mines										
Nickel-copper-zinc	Own equipment	111 189	13 423	124 612	173 155	3 046	176 201	202 223	308 471	510 694
	Contractors	203 357	58 971	262 328	263 209	73 335	336 544	319 842	-	319 842
	Total	314 546	72 394	386 940	436 364	76 381	512 745	522 065	308 471	830 536
Gold	Own equipment	57 957	3 262	61 219	40 381	2 240	42 621	38 223	1 062	39 285
	Contractors	227 202	-	227 202	263 513	46 084	309 597	362 358	4 417	366 775
	Total	285 159	3 262	288 421	303 894	48 324	352 218	400 581	5 479	406 060
Silver-lead-zinc	Own equipment	79 110	171 989	251 099	69 863	75 852	145 715	67 559	4 772	72 281
	Contractors	173 119	-	173 119	123 944	-	123 944	200 957	-	200 957
	Total	252 229	171 989	424 218	193 807	75 852	269 695	268 516	4 772	273 238
Iron mines	Own equipment	-	-	-	-	-	-	-	178 684	178 684
	Contractors	22 067	-	22 067	728	-	728	660	-	660
	Total	22 067	-	22 067	728	-	728	660	178 684	179 344
Uranium	Own equipment	41 645	-	41 645	40 984	-	40 984	47 675	-	47 675
	Contractors	45 714	13 362	59 076	34 453	-	34 453	23 716	-	23 716
	Total	87 359	13 362	100 721	75 437	-	75 437	71 391	-	71 391
Miscellaneous metal mining	Own equipment	-	-	-	-	-	-	2 000	-	2 000
	Contractors	41 954	-	41 954	21 496	-	21 496	28 926	-	28 926
	Total	41 954	-	41 954	21 496	-	21 496	30 926	-	30 926
Total metal mining	Own equipment	289 901	188 674	478 575	324 383	81 138	405 521	357 680	492 939	850 619
	Contractors	713 413	72 333	785 746	707 343	119 419	826 762	936 459	4 417	940 876
	Total	1 003 314	261 007	1 264 321	1 031 726	200 557	1 232 283	1 294 139	497 356	1 791 495
Nonmetal mines										
Miscellaneous nonmetal mining	Own equipment	1 073	-	1 073	2 220	-	2 220	360	-	360
	Contractors	3 596	-	3 596	9 159	-	9 159	4 191	-	4 191
	Total	4 669	-	4 669	11 379	-	11 379	4 551	-	4 551
Gypsum	Own equipment	-	-	-	-	-	-	-	-	-
	Contractors	-	-	-	762	-	762	3 319	-	3 319
	Total	-	-	-	762	-	762	3 319	-	3 319
Asbestos	Own equipment	-	-	-	-	-	-	-	-	-
	Contractors	8 400	-	8 400	-	-	-	3 293	-	3 293
	Total	8 400	-	8 400	-	-	-	3 293	-	3 293
Total nonmetal mining	Own equipment	1 073	-	1 073	2 220	-	2 220	360	-	360
	Contractors	11 996	-	11 996	9 921	-	9 921	10 803	-	10 803
	Total	13 069	-	13 069	12 141	-	12 141	11 163	-	11 163
Total mining industry	Own equipment	290 974	188 674	479 648	326 603	81 138	407 741	358 040	939	850 979
	Contractors	725 409	72 333	797 742	717 264	119 419	836 683	947 262	4 417	951 679
	Total	1 016 383	261 007	1 277 390	1 043 867	200 557	1 244 424	1 305 302	497 356	1 802 658

- Nil.

TABLE 60. CANADA, ORE MINED AND ROCK QUARRIED IN THE MINING INDUSTRY, 1955-84

	Metals	Industrials[1]	Coal	Total
		(million tonnes)		
1955	62.7	57.6		120.3
1956	70.2	66.2		136.4
1957	76.4	74.5		150.9
1958	71.4	71.2		142.6
1959	89.9	82.2		172.1
1960	92.1	88.7		180.8
1961	90.1	96.7		186.8
1962	103.6	103.8		207.4
1963	112.7	120.4		233.1
1964	128.0	134.1		262.1
1965	151.0	146.5		297.5
1966	147.6	171.8		319.4
1967	169.1	177.5		346.6
1968	186.9	172.7		359.6
1969	172.0	178.8		350.8
1970	213.0	179.1		392.1
1971	211.5	185.8		397.3
1972	206.0	189.7		395.7
1973	274.8	162.6		437.3
1974	278.7	178.8		457.6
1975	264.2	158.7		422.9
1976	296.5	167.1		463.6
1977	299.5	205.2	33.8	538.6
1978	248.1	205.5	36.3	489.8
1979	274.8	197.7	39.8	512.2
1980	290.1	190.3	43.9	524.3
1981	301.5	169.7	48.2	519.5
1982	238.4	119.1	53.0	410.4
1983	219.0	134.0	54.8	407.9
1984	246.4	164.0	71.2	481.6

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[1] Includes nonmetallic mineral mining and all stone quarried, including stone used to make cement and lime. From 1977 onwards, coverage is the same as in Table 56.

TABLE 61. CANADA, TOTAL DIAMOND DRILLING, METAL DEPOSITS, 1955-84

	Gold Deposits	Copper-zinc- and nickel-copper Deposits	Silver-lead- zinc Deposits	Other Metal Bearing Deposits[1]	Total Metal Deposits
			(metres)		
1955	717 674	875 942	341 857	537 612	2 473 085
1956	682 600	1 490 298	399 679	383 431	2 956 008
1957	706 273	1 098 490	323 704	287 364	2 415 831
1958	546 861	923 026	297 792	286 970	2 054 649
1959	558 160	1 110 664	282 088	383 471	2 334 383
1960	628 016	1 267 792	226 027	315 067	2 436 902
1961	503 741	1 128 091	255 101	221 079	2 199 452
1962	902 288	1 025 048	350 180	358 679	2 636 195
1963	529 958	977 257	288 204	148 703	1 944 122
1964	458 933	709 588	401 099	104 738	1 674 358
1965	440 020	779 536	331 294	275 917	1 826 727
1966	442 447	729 148	292 223	164 253	1 628 071
1967	391 347	947 955	230 182	120 350	1 689 834
1968	375 263	935 716	198 038	56 780	1 565 797
1969	274 410	923 452	197 670	109 592	1 505 124
1970	214 717	1 132 915	375 019	99 373	1 822 024
1971	193 291	1 089 103	308 798	83 851	1 675 043
1972	229 771	967 640	240 195	50 225	1 487 831
1973	243 708	713 134	185 946	57 730	1 200 518
1974	250 248	798 564	197 322	83 484	1 329 618
1975	216 158	532 991	184 203	97 971	1 031 323
1976	156 030	507 620	166 366	97 735	927 751
1977	175 643	515 780	213 279	124 329	1 029 031
1978	209 335	227 065	490 489	135 197	1 181 743
1979	198 955	437 562	131 032	150 018	917 567
1980	187 635	566 610	259 877	173 945	1 188 067
1981	306 197	675 712	478 754	170 369	1 631 032
1982	288 421	386 940	424 218	164 742	1 264 321
1983	352 218	512 745	269 659	97 661	1 232 283
1984	406 060	830 536	273 238	281 661	1 791 495

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[1] Includes iron, titanium, uranium, molybdenum and other metal deposits.

TABLE 62. CANADA, EXPLORATION DIAMOND DRILLING, METAL DEPOSITS, 1955-84

	Mining Companies with Own Personnel and Equipment	Diamond Drill Contractors	Total
		(metres)	
1955	464 118	1 546 025	2 010 143
1956	474 562	1 644 735	2 119 297
1957	358 300	1 233 323	1 591 623
1958	237 133	1 200 625	1 437 758
1959	239 786	1 367 061	1 606 847
1960	268 381	1 409 416	1 677 797
1961	302 696	1 337 173	1 639 869
1962	167 214	1 748 023	1 915 237
1963	361 180	1 169 292	1 530 472
1964	143 013	1 072 985	1 215 998
1965	209 002	1 176 996	1 385 998
1966	163 379	1 044 860	1 208 239
1967	93 164	1 123 137	1 216 301
1968	159 341	990 690	1 150 031
1969	135 311	1 072 328	1 207 639
1970	62 147	1 228 061	1 290 208
1971	86 838	1 053 330	1 140 168
1972	251 651	839 753	1 091 404
1973	321 333	742 899	1 064 232
1974	357 823	892 557	1 250 380
1975	346 770	618 161	964 931
1976	335 919	532 036	867 955
1977	327 241	638 327	965 568
1978	237 250	534 557	771 807
1979	311 221	571 721	882 942
1980	347 829	747 566	1 095 395
1981	460 687	917 566	1 378 253
1982	289 901	713 413	1 003 314
1983	324 383	707 343	1 031 726
1984	357 680	936 459	1 294 139

TABLE 63. CANADA, DIAMOND DRILLING OTHER THAN FOR EXPLORATION, METAL DEPOSITS, 1955-84

	Mining Companies with Own Personnel and Equipment	Diamond Drill Contractors	Total
		(metres)	
1955	410 925	52 017	462 942
1956	790 522	46 188	836 710
1957	524 724	156 060	680 784
1958	444 376	172 516	616 892
1959	488 783	238 753	727 536
1960	450 246	308 860	759 105
1961	384 432	175 149	559 581
1962	528 700	192 259	720 959
1963	388 228	25 422	413 650
1964	385 765	72 594	458 359
1965	393 947	46 822	440 769
1966	227 968	191 863	419 831
1967	186 463	287 071	473 534
1968	122 851	292 914	415 765
1969	87 552	209 933	297 485
1970	290 363	241 453	531 816
1971	295 966	238 910	534 876
1972	304 523	91 903	396 426
1973	77 162	59 124	136 286
1974	54 353	24 885	79 238
1975	31 917	34 475	66 392
1976	31 413	28 383	59 796
1977	24 303	39 160	63 463
1978	351 344	58 592	409 936
1979	4 090	30 535	34 625
1980	20 545	72 127	92 672
1981	200 898	51 881	252 779
1982	188 674	72 333	261 007
1983	81 138	119 419	200 557
1984	492 939	4 417	497 356

Nonproducing companies excluded since 1964.

TABLE 64. CANADA, CRUDE MINERALS TRANSPORTED BY CANADIAN RAILWAYS, 1982-84

	1982	1983	1984
		(kilotonnes)	
Metallic minerals			
Iron ores and concentrates	35 101	30 281	49 231
Nickel-copper ores and concentrates	1 890	2 738	4 240
Alumina and bauxite	2 793	3 091	3 538
Zinc ores and concentrates	1 638	1 571	2 232
Copper ores and concentrates	1 507	1 488	1 727
Lead ores and concentrates	545	588	1 577
Nickel ores and concentrates	228	97	-
Metallic ores and concentrates, nes	345	73	44
Total metallic minerals	44 047	39 927	62 589
Nonmetallic minerals			
Potash (KCl)	7 681	9 239	11 008
Sulphur, nes	4 855	4 477	5 956
Gypsum	3 591	5 065	5 530
Limestone, nes	3 049	2 715	2 840
Phosphate rock	1 665	2 017	2 217
Sulphur, liquid	1 518	1 440	2 089
Salt, rock	1 078	941	999
Sand, industrial	743	816	964
Clay	485	534	686
Sodium carbonate	481	484	545
Sodium sulphate	623	496	503
Nepheline syenite	274	291	450
Sand, nes	10	263	320
Limestone, industrial	177	257	264
Nonmetallic minerals, nes	152	143	194
Limestone, agricultural	42	59	103
Salt, nes	83	112	102
Asbestos	190	120	101
Stone, nes	93	117	68
Abrasives, natural	37	32	44
Peat and other mosses	23	19	27
Barite	21	44	26
Silica	12	13	12
Total nonmetallic minerals	26 883	29 713	35 048
Mineral fuels			
Coal, bituminous	23 293	24 284	37 952
Coal, lignite	1 312	1 235	1 636
Coal, nes	68	70	122
Natural gas and other crude bituminous substances	7	11	28
Oil, crude	91	50	4
Total mineral fuels	24 771	25 650	39 742
Total crude minerals	95 701	95 290	137 379
Total revenue freight moved by Canadian railways	212 542	222 830	286 375
Per cent crude minerals of total revenue freight	45.0	42.8	48.0

nes Not elsewhere specified; - Nil.

TABLE 65. CANADA, FABRICATED MINERAL PRODUCTS TRANSPORTED BY CANADIAN RAILWAYS, 1982-84

	1982	1983	1984
	(kilotonnes)		
Metallic mineral products			
Ferrous mineral products			
Iron and steel scrap	1 162	1 720	2 606
Ingots, blooms, billets, slabs of iron and steel	630	1 300	1 564
Sheets and strips, steel	666	657	1 244
Bars and rods, steel	521	642	797
Plates, steel	314	413	580
Structural shapes and sheet piling, iron and steel	216	282	565
Pipes and tubes, iron and steel	448	209	449
Castings and forgings, iron and steel	114	125	160
Rails and railway track material	94	108	137
Pig iron	42	50	80
Ferroalloys	47	45	71
Other primary iron and steel	21	20	43
Wire, iron or steel	21	12	14
Total ferrous mineral products	4 296	5 583	8 310
Nonferrous mineral products			
Aluminum and aluminum alloy fabricated material, nes	234	733	1 110
Zinc and alloys	406	484	663
Copper and alloys, nes	350	423	631
Other nonferrous base metals and alloys	13	13	188
Aluminum paste, powder, pigs, ingots, shot	291	252	162
Lead and alloys	119	146	160
Nonferrous metal scrap	109	94	138
Slag, dross, etc.	52	126	138
Copper matte and precipitates	351	5	4
Total nonferrous mineral products	1 925	2 276	3 194
Total metallic mineral products	6 221	7 859	11 504
Nonmetallic mineral products			
Fertilizers and fertilizer materials, nes	1 581	1 747	2 574
Sulphuric acid	957	1 067	2 122
Portland cement, standard	1 349	1 589	1 486
Nonmetallic mineral basic products, nes	299	268	367
Gypsum basic products, nes	21	108	206
Natural stone basic products, chiefly structural	160	193	205
Cement and concrete basic products, nes	173	245	187
Lime, hydrated and quick	186	156	167
Dolomite and magnesite, calcined	39	55	83
Glass basic products	84	72	59
Fire brick and similar shapes	47	32	56
Bricks and tiles, clay	20	20	10
Refractories, nes	16	12	13
Asbestos and asbestos-cement basic products	23	4	11
Plaster	13	11	6
Total nonmetallic mineral products	4 968	6 644	7 552
Mineral fuel products			
Refined and manufactured gases, fuel type	2 991	2 753	3 089
Diesel fuel	2 223	2 053	2 099
Gasoline	1 376	1 332	1 449
Fuel oil, nes	890	829	1 088
Other petroleum and coal products	676	758	833
Coke, nes	567	606	678
Petroleum coke	537	467	552
Lubricating oils and greases	296	330	435
Asphalts and road oils	256	183	301
Total mineral fuel products	9 812	9 311	10 524
Total fabricated mineral products	21 001	23 814	29 580
Total revenue freight moved by Canadian railways	212 542	222 030	286 375
Fabricated mineral products as a percentage of total revenue freight	9.9	10.7	10.3

nes Not elsewhere specified.

TABLE 66. CANADA, CRUDE AND FABRICATED MINERALS TRANSPORTED BY CANADIAN RAILWAYS, 1955-84

	Total Revenue Freight	Total Crude Minerals	Total Fabricated Minerals	Total Crude and Fabricated Minerals	Crude and Fabricated Minerals as Per cent of Revenue Freight
1955	152.2	61.2	19.0	80.2	52.7
1956	172.0	68.7	21.8	90.5	52.6
1957	157.9	64.2	17.1	81.3	51.5
1958	139.2	52.4	15.2	67.6	48.6
1959	150.6	62.8	15.3	78.1	52.9
1960	142.8	57.1	14.5	71.6	50.1
1961	138.9	54.1	13.6	67.7	48.7
1962	146.0	60.3	13.8	74.1	50.8
1963	154.6	62.9	15.5	78.3	50.6
1964	180.0	74.6	15.9	90.5	50.3
1965	186.2	80.9	17.3	98.2	52.7
1966	194.5	80.6	17.8	98.4	50.6
1967	190.0	81.2	17.7	98.9	52.1
1968	195.4	86.7	18.8	105.5	54.0
1969	189.0	81.9	27.6	109.5	57.9
1970	211.6	97.5	28.4	127.9	60.4
1971	214.5	95.6	27.4	123.0	57.3
1972	215.8	89.4	27.6	117.0	54.2
1973	241.2	113.1	29.1	142.2	59.0
1974	246.3	115.3	30.9	146.2	59.4
1975	226.0	110.6	26.6	137.2	60.7
1976	238.5	116.6	25.5	142.1	59.6
1977	247.2	121.1	25.7	146.8	59.4
1978	238.8	107.7	26.2	133.9	45.1
1979	257.9	127.2	26.6	153.8	59.6
1980	254.4	124.8	24.6	149.4	58.8
1981	246.6	120.7	26.4	147.1	59.7
1982	212.5	95.7	21.0	116.7	54.9
1983	222.8	95.3	23.8	119.1	53.5
1984	286.3	137.4	29.6	167.0	58.3

TABLE 67. CANADA, CRUDE AND FABRICATED MINERALS TRANSPORTED THROUGH THE ST. LAWRENCE SEAWAY[1], 1983-85

	Montreal - Lake Ontario Section			Welland Canal Section		
	1983	1984	1985	1983	1984	1985
		(tonnes)			(tonnes)	
Crude minerals						
Iron ore	10 280 210	11 421 521	8 679 210	9 229 290	10 088 727	6 788 799
Coal	350 170	452 898	607 108	5 494 597	6 603 148	5 807 694
Salt	878 535	898 931	657 494	1 455 070	1 725 967	1 521 180
Other crude minerals	651 140	842 988	1 099 291	419 199	694 588	732 510
Stone, ground or crushed	47 462	117 233	258 745	401 719	537 585	815 313
Aluminum ores and concentrates	115 345	185 500	200 890	115 345	185 452	198 890
Sand and gravel	7 975	6 992	1	203 063	318 736	176 291
Clay and bentonite	76 849	157 206	162 410	76 849	157 206	162 410
Phosphate rock	35 156	5 484	23 522	16 326	-	-
Stone, rough	292	206	302	289	206	302
Total crude minerals	12 443 134	14 088 959	11 688 973	17 411 747	20 311 615	16 203 389
Fabricated mineral products						
Iron and steel, manufactured	2 605 115	3 566 220	2 798 848	2 416 949	3 182 737	2 407 431
Coke	638 042	793 112	802 266	683 081	858 598	921 887
Scrap iron and steel	390 006	303 619	635 622	366 974	325 725	753 927
Iron and steel, bars, rods, slabs	286 838	861 123	791 144	361 841	769 358	675 205
Fuel oil	936 121	745 378	558 770	835 489	678 186	628 613
Cement	2 522	10	175 111	409 794	531 399	309 120
Gasoline	249 993	237 388	111 419	218 092	251 160	141 601
Pig iron	161 017	243 817	103 610	150 896	218 538	89 263
Other petroleum products	110 029	134 353	84 179	116 155	134 139	76 295
Tar, pitch and creosote	25 154	51 533	35 892	43 015	74 189	69 324
Lubricating oils and greases	13 070	17 430	41 964	12 889	17 106	41 962
Iron and steel, nails, wire	4 184	25 888	13 229	3 305	10 822	12 287
Total fabricated minerals	5 422 091	6 979 871	6 162 054	5 618 479	7 051 957	6 126 915
Total crude and fabricated minerals	17 865 225	20 988 830	17 841 027	23 030 226	27 363 572	22 330 304
Total, all products	45 060 981	47 505 456	37 321 698	50 145 086	53 916 858	41 851 760
Crude and fabricated minerals as a per cent of total	39.6	44.2	47.8	45.9	50.8	53.4

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[1] Total cargo transported regardless of travel direction.
- Nil.

TABLE 68. CANADA, CRUDE AND FABRICATED MINERALS TRANSPORTED THROUGH THE ST. LAWRENCE SEAWAY[1], 1956-85

	Montreal - Lake Ontario Section				Welland Canal Section			
	Total, All Products	Total Crude Minerals	Total Fabricated Minerals	Crude and Fabricated Minerals as Per cent of All Products	Total, All Products	Total Crude Minerals	Total Fabricated Minerals	Crude and Fabricated Minerals as Per cent of All Products
	(kilotonnes)				(kilotonnes)			
1956	12 247	4 807	1 314	50.0	20 925	11 405	2 169	64.8
1957	11 059	4 439	1 392	52.7	20 296	11 305	2 421	67.6
1958	10 670	3 064	1 020	38.3	19 300	8 994	2 107	57.5
1959	19 252	7 725	2 197	51.5	24 953	12 117	2 246	57.6
1960	18 460	5 760	2 904	46.9	26 563	12 679	2 606	57.5
1961	21 212	6 706	2 358	42.7	28 490	12 599	2 378	52.7
1962	23 271	7 531	2 522	43.2	32 215	15 625	2 342	55.8
1963	28 198	9 507	2 804	43.7	37 490	18 094	2 524	55.0
1964	35 701	13 127	3 558	46.7	46 644	23 489	3 095	57.0
1965	39 352	13 788	6 024	50.3	48 477	23 555	4 933	58.8
1966	44 538	16 376	6 340	51.0	53 648	25 712	5 329	57.8
1967	39 918	17 800	6 430	60.7	47 945	26 010	5 459	65.6
1968	43 496	19 312	8 425	63.8	52 712	29 075	7 587	69.6
1969	37 256	12 682	8 263	56.2	48 601	25 090	6 715	65.4
1970	46 445	15 554	8 932	52.7	57 121	27 233	7 156	60.2
1971	48 069	14 204	9 263	48.8	57 205	23 903	7 914	55.6
1972	48 607	13 425	9 837	47.9	58 146	24 808	7 701	55.9
1973	52 285	17 111	9 639	51.1	60 958	26 907	7 718	56.8
1974	40 049	16 137	7 018	57.8	47 500	23 952	5 437	61.9
1975	43 554	15 698	6 071	50.0	53 387	26 100	5 129	58.5
1976	49 348	20 884	7 181	56.9	58 368	29 914	6 323	62.1
1977	57 456	23 008	9 918	57.3	65 079	30 459	8 933	60.5
1978	51 658	15 057	8 558	45.7	59 576	22 700	7 759	51.1
1979	50 187	16 408	8 104	48.8	60 023	24 851	7 940	54.6
1980	42 142	12 248	6 009	43.3	54 074	20 487	5 405	47.9
1981	45 876	15 453	5 711	46.1	53 389	22 132	5 529	51.8
1982	38 841	9 146	4 997	36.4	44 474	15 057	4 333	45.9
1983	45 061	12 443	5 422	39.6	50 145	17 412	5 618	45.9
1984	47 505	14 009	6 980	44.2	53 917	20 312	7 056	50.8
1985	37 322	11 689	6 152	47.8	41 852	16 203	6 127	53.4

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[1] Total cargo transported regardless of travel direction.

TABLE 69. CANADA, CRUDE MINERALS LOADED AND UNLOADED IN COASTWISE SHIPPING, 1985

	Loaded				Unloaded			
	Atlantic	Great Lakes	Pacific	Total	Atlantic	Great Lakes	Pacific	Total
				(tonnes)				
Metallic minerals								
Iron ore and concentrates	4 501 655	576 919	1 361	5 079 935	576 886	4 501 688	1 361	5 079 935
Titanium ore	2 504 242	-	-	2 504 242	2 504 242	-	-	2 504 242
Zinc ore and concentrates	7 646	-	22 306	29 954	7 646	-	22 308	29 954
Metallic ores and concentrates	11 328	-	-	11 328	1 688	9 640	-	11 328
Total metals	7 024 871	576 919	23 669	7 625 459	3 090 462	4 511 328	23 669	7 625 459
Nonmetallic minerals								
Limestone	3 041	2 880 778	1 446 776	4 330 595	97 079	2 786 740	1 446 776	4 330 595
Salt	1 157 966	1 196 609	-	2 354 575	1 510 723	835 852	8 000	2 354 575
Sand and gravel	338 803	-	570 294	909 097	338 803	-	570 294	909 097
Gypsum	896 644	-	9 979	906 623	631 940	264 704	9 979	906 623
Stone, crude, nes	1 070	352 157	4 203	357 430	1 070	352 157	4 203	357 430
Potash	2 309	238 015	-	240 324	40 956	199 368	-	240 324
Quartz-silica	25 968	-	1 339	27 307	-	25 968	1 339	27 307
Dolomite	-	25 006	-	25 006	25 006	-	-	25 006
Sulphur crude and refined	9 163	-	7 796	16 959	9 163	-	7 796	16 959
Phosphate rock	10 982	-	-	10 982	10 982	-	-	10 982
Crude nonmetallic minerals, nes	2 124	41	68	2 233	2 124	41	68	2 233
Total nonmetals	2 448 070	4 692 606	2 040 455	9 181 131	2 667 846	4 464 830	2 040 455	9 181 131
Mineral fuels								
Coal and peat for fuel	72 524	2 000 067	60 879	2 133 470	104 424	2 000 067	28 979	2 133 470
Petroleum, crude	914 523	9 668	-	924 191	924 191	-	-	924 191
Total mineral fuels	987 047	2 009 735	60 879	3 057 661	1 028 615	2 000 067	28 879	3 057 661
Total crude minerals	10 459 988	7 279 260	2 125 003	19 864 251	6 786 923	10 976 225	2 101 103	19 864 251
Total all commodities	18 389 272	22 164 497	21 152 538	61 706 307	25 291 378	15 293 558	21 121 372	61 706 307
Crude minerals as a per cent of all commodities	56.8	32.8	10.0	32.2	26.8	71.8	9.9	32.2

- Nil; nes Not elsewhere specified.

TABLE 70. CANADA, FABRICATED MINERALS LOADED AND UNLOADED IN COASTWISE SHIPPING, 1985

	Loaded				Unloaded			
	Atlantic	Great Lakes	Pacific	Total	Atlantic	Great Lakes	Pacific	Total
				(tonnes)				
Metallic mineral products								
Ferrous mineral products								
Structual shapes, iron and steel	7 360	63 086	53 130	123 576	7 360	63 086	53 130	123 576
Plates and sheets, steel	540	25 281	-	25 821	540	25 281	-	25 281
Primary iron, steel	14 346	-	-	14 346	-	14 346	-	14 346
Ferroalloys	5 604	-	-	5 604	-	5 604	-	5 604
Castings and forgings, steel	846	-	3 298	4 144	846	-	3 298	4 144
Bars and rods, steel	1 352	-	-	1 352	1 352	-	-	1 352
Pipes and tubes, iron and steel	1 141	-	-	1 141	1 141	-	-	1 141
Wire, iron and steel	718	-	-	718	718	-	-	718
Rails and railway track material	88	312	-	400	400	-	-	400
Aluminum and aluminum products	60 962	-	-	60 962	60 962	-	-	60 962
Total metallic mineral products	92 957	88 679	56 428	238 064	73 319	108 317	56 428	238 064
Nonmetallic mineral products								
Cement	10 129	497 385	79 050	586 564	35 129	472 385	79 050	586 564
Sulphuric acid	-	-	19 495	19 495	-	-	19 495	19 495
Bricks, tiles and pipes, clay	3 949	86	39	4 074	3 949	86	39	4 074
Fertilizers and fertilizer material, nes	737	-	2 449	3 186	737	-	2 449	3 186
Other nonmetallic mineral products	2 930	-	4 572	7 502	2 930	-	4 572	7 502
Cement basic products	373	-	-	373	373	-	-	373
Glass basic products	44	-	-	44	44	-	-	44
Total nonmetallic mineral products	18 162	497 471	105 605	621 238	43 162	472 471	105 605	621 238
Mineral fuel products								
Fuel oil	4 083 870	795 483	1 163 418	6 042 771	4 295 348	584 005	1 163 418	6 042 771
Gasoline	2 124 129	411 377	541 108	3 076 615	2 147 211	388 296	541 108	3 076 615
Petroleum coke	136 341	24 775	17 681	178 797	161 116	-	17 681	178 797
Asphalts and road oils	29 978	46 641	4 536	81 155	24 181	52 438	4 536	81 155
Lubricating oils and greases	33 556	2 338	23	35 917	10 807	25 087	23	35 917
Other petroleum and coal products	12 867	13 144	-	26 010	26 010	-	-	26 010
Total mineral fuel products	6 420 741	1 293 758	1 726 766	9 441 265	6 664 673	1 049 826	1 726 766	9 441 265
Total fabricated mineral products	6 531 860	1 879 908	1 888 799	10 300 567	6 781 154	1 630 614	1 888 799	10 300 567
Total all commodities	18 389 272	22 164 497	21 152 538	61 706 307	25 291 378	15 293 558	21 121 372	61 706 307
Fabricated mineral products as a per cent of all commodities	35.5	8.5	8.9	16.7	26.8	10.7	8.9	16.7

- Nil; nes Not elsewhere specified.

TABLE 71. CANADA, CRUDE AND FABRICATED MINERALS LOADED AT CANADIAN PORTS IN COASTWISE SHIPPING; 1956-85

	Total All Commodities	Total Crude Minerals	Total Fabricated Minerals	Crude and Fabricated Minerals as Per cent of All Products
		(kilotonnes)		
1956	31 303	6 750	7 275	44.8
1957	34 354	8 696	7 832	48.1
1958	34 808	7 673	7 258	42.9
1959	36 494	9 984	7 819	48.8
1960	37 058	8 786	8 229	45.9
1961	41 861	9 527	8 857	43.9
1962	39 763	8 361	9 768	45.6
1963	40 328	7 998	9 942	44.5
1964	47 171	8 522	11 194	41.8
1965	48 200	9 183	11 766	43.5
1966	55 122	10 155	12 653	41.4
1967	49 799	11 509	12 207	47.6
1968	50 921	13 698	13 245	52.9
1969	51 890	12 746	14 181	51.9
1970	57 301	14 415	14 818	51.0
1971	55 128	14 783	15 374	54.7
1972	55 326	14 197	15 290	53.3
1973	55 314	16 573	15 615	58.2
1974	53 633	11 723	16 575	52.8
1975	54 373	15 687	17 510	61.1
1976	53 882	15 924	16 208	59.6
1977	58 309	18 131	17 435	61.0
1978	60 668	18 318	16 619	57.6
1979	79 950	22 130	17 486	50.2
1980	82 761	22 947	17 134	48.4
1981	71 271	17 849	16 669	48.4
1982	65 881	16 473	13 214	45.1
1983	67 598	21 248	12 025	49.2
1984	68 698	22 798	11 909	50.5
1985	61 706	19 864	9 441	47.5

TABLE 72. CANADA, CRUDE MINERALS LOADED AND UNLOADED AT CANADIAN PORTS IN INTERNATIONAL SHIPPING TRADE, 1983-85

	1983		1984		1985P	
	Loaded	Unloaded	Loaded	Unloaded	Loaded	Unloaded
				(tonnes)		
Metallic minerals						
Iron ore and concentrates	26 803 303	4 364 451	31 005 195	5 565 570	32 669 305	6 431 342
Copper ores and concentrates	1 137 386	77 460	1 129 159	102 695	1 179 258	224 479
Titanium ore	683 513	8 035	743 771	14 204	1 032 233	3 782
Zinc ore and concentrates	937 716	277	821 896	299	655 418	160
Nickel ore and concentrates	92 033	18 229	120 390	8 730	113 252	6 053
Lead ore and concentrates	350 835	7 396	65 567	7 551	110 289	1 916
Other nonferrous ores, concentrates and metal scrap, nes	108 120	30 808	87 948	26 125	108 666	67 437
Alumina, bauxite ore	9 225	3 561 112	42 803	3 655 040	45 842	3 320 373
Manganese ore	10 555	108 112	-	188 864	2 522	182 024
Total metals	30 132 686	8 175 880	34 016 729	9 569 078	35 916 785	10 237 566
Nonmetallic minerals						
Gypsum	5 415 167	104 599	5 556 660	126 685	5 796 077	77 902
Sulphur	4 687 209	5	5 848 191	3	5 334 205	-
Potash (KCl)	4 659 250	37	5 987 217	1 544	4 747 898	79 292
Salt	1 838 079	741 470	2 673 379	980 128	2 053 809	1 317 086
Limestone	1 690 721	1 786 294	1 508 547	1 619 486	1 090 691	861 734
Stone, crushed	34 186	19	91 946	20	875 543	991 178
Asbestos	648 320	638	552 180	559	506 633	727
Dolomite	410 440	17 319	631 129	12 914	359 207	17 674
Sand and gravel	34 212	1 040 504	42 389	1 548 098	249 990	1 489 944
Stone, crude, nes	25 801	17 195	35 953	35 770	95 879	91 446
Crude, nonmetallic minerals, nes	100 411	59 304	149 080	20 378	95 074	24 213
Phosphate rock	-	1 317 237	-	1 836 376	2 200	1 557 629
Clay materials, nes	519	4 629	745	7 216	1 236	1 541
Bentonite	15 012	99 488	26	152 262	165	176 349
China clay	132	26 415	-	21 179	54	15 379
Fluorspar	-	127 681	-	119 602	-	114 081
Barite	-	25 668	-	10 668	-	8 012
Total nonmetals	19 599 459	5 368 502	23 077 442	6 492 888	21 208 661	6 824 187
Mineral fuels						
Coal, bituminous	16 901 990	14 884 124	25 395 206	18 577 598	25 637 612	15 220 304
Petroleum, crude	517 290	7 432 267	230 035	8 310 602	694 576	9 693 288
Fuels, nes	397	240 663	32 970	109	343	2 565
Total fuels	17 419 677	22 557 054	25 658 211	26 888 309	26 332 531	24 916 157
Total crude minerals	67 151 822	36 101 436	82 752 382	42 950 275	83 457 977	41 977 910
Total all commodities	129 490 483	48 914 996	145 322 054	60 072 623	143 527 980	60 762 905
Crude minerals as a per cent of all commodities	51.9	73.8	56.9	71.5	58.1	69.1

- Nil; nes Not elsewhere specified; P Preliminary.

TABLE 73. CANADA, FABRICATED MINERAL PRODUCTS LOADED AND UNLOADED AT CANADIAN PORTS IN INTERNATIONAL SHIPPING TRADE, 1983-85

	1983		1984		1985P	
	Loaded	Unloaded	Loaded	Unloaded	Loaded	Unloaded
			(tonnes)			
Metallic products						
Iron, pig	397 316	1 500	341 316	114 726	461 493	104 793
Iron and steel, other						
plates and sheets	135 406	272 898	211 081	472 314	285 156	543 381
bars and rods	56 048	186 667	46 229	280 668	45 606	291 397
castings and forgings	33 235	55 823	16 004	141 290	43 478	129 390
rails and track material	25 179	13 639	56 903	22 461	29 946	62 771
pipes and tubes	15 043	117 069	13 312	213 191	28 010	315 427
wire and rope	24 434	149 730	19 334	200 094	14 141	176 208
structural shapes	137 749	88 282	33 317	137 938	9 267	132 351
Aluminum	339 355	61 182	299 463	109 309	446 744	98 339
Iron and steel, primary	26 681	9 561	402 526	2 960	425 065	2 339
Copper and alloys	219 095	47 933	189 132	61 686	176 556	45 850
Zinc and alloys	140 079	21 350	144 875	14 105	124 582	2 682
Nickel and alloys	35 297	8 111	51 337	37 775	45 156	33 752
Ferroalloys	19 530	39 763	35 958	27 405	45 026	39 117
Lead and alloys	59 190	3 247	19 773	3 594	21 844	801
Nonferrous metals, nes	68 620	37 728	6 310	24 374	8 143	32 995
Total metals	1 733 287	1 115 483	1 886 870	1 863 890	2 210 213	2 016 593
Nonmetallic products						
Cement	1 010 708	8 347	1 257 406	1 645	1 045 743	69 216
Cement basic products	40 770	1 643	282 120	8 242	533 236	81 305
Fertilisers, nes	83 563	236 475	566 091	365 746	224 809	200 035
Sulphuric acid	90 037	5 998	264 567	75	188 554	669 358
Nonmetallic mineral basic products	30 210	92 468	61 147	76 918	26 271	365 775
Building blocks, nes	21 438	128 401	17 216	148 009	17 471	186 509
Glass basic products	30 249	20 501	17 490	26 520	8 698	46 786
Asbestos basic products	2 444	563	6 367	788	1 972	630
Total nonmetals	1 309 419	494 396	2 472 404	627 943	2 046 754	1 619 614
Mineral fuel products						
Fuel oil	1 829 947	1 851 282	2 108 901	3 583 063	2 971 329	2 887 106
Gasoline	532 633	453 430	827 837	397 768	1 571 583	793 972
Coke	414 853	958 263	415 309	1 015 868	1 313 230	1 169 141
Petroleum and coal products, nes	357 494	1 236	211 737	58 759	1 004 952	154 065
Asphalts, road oils	3 416	9 871	31 904	58 749	12 777	58 778
Lubricating oils and greases	8 361	6 678	18 247	25 182	8 592	22 806
Coal tar, pitch	7 506	78 570	12 459	56 574	5 978	77 134
Total fuels	3 154 210	3 359 330	3 626 394	5 195 963	6 888 441	5 163 002
Total fabricated mineral products	6 196 916	4 969 209	7 985 668	7 687 796	11 145 408	8 799 209
Total, all commodities	129 490 483	48 914 996	145 322 054	60 072 623	143 527 980	60 762 905
Fabricated mineral products as a per cent of all commodities	4.8	10.2	5.5	12.8	7.8	14.5

P Preliminary; nes Not elsewhere specified.

TABLE 74. CANADA, CRUDE AND FABRICATED MINERALS LOADED AT CANADIAN PORTS IN INTERNATIONAL SHIPPING TRADE, 1956-85

	Total All Commodities	Total Crude Minerals	Total Fabricated Minerals	Crude and Fabricated Minerals as Per cent of All Products
		(kilotonnes)		
1956	44 791	23 284	1 904	56.2
1957	44 539	24 210	2 588	60.2
1958	36 559	16 602	1 642	49.9
1959	45 772	25 789	1 619	59.9
1960	45 872	24 671	2 039	58.2
1961	48 771	23 241	2 133	52.0
1962	54 676	30 446	2 296	59.9
1963	62 031	32 214	2 503	56.0
1964	75 760	42 087	2 602	59.0
1965	74 521	41 338	2 746	59.2
1966	76 192	41 374	3 350	58.7
1967	72 598	42 704	3 701	63.9
1968	78 663	48 680	2 960	65.6
1969	70 432	42 442	3 456	65.1
1970	95 807	55 849	4 965	63.5
1971	95 887	53 245	5 022	60.7
1972	98 988	51 912	9 091	61.6
1973	112 434	64 195	10 103	66.1
1974	106 110	64 093	9 041	68.9
1975	102 444	61 970	7 495	67.8
1976	114 815	71 527	6 108	67.6
1977	119 770	70 257	5 979	63.7
1978	116 522	62 291	7 556	59.9
1979	134 639	79 685	8 901	65.8
1980	138 161	67 898	11 770	57.7
1981	145 445	83 007	9 022	63.3
1982	125 282	65 594	7 115	58.1
1983	129 490	67 152	6 197	56.7
1984	145 322	82 752	7 986	62.4
1985P	143 528	83 458	11 145	65.9

P Preliminary.

TABLE 75. CANADA, FINANCIAL STATISTICS OF CORPORATIONS IN THE MINING INDUSTRY[1] BY DEGREE OF NON-RESIDENT OWNERSHIP, 1983

	Corporations		Assets		Equity		Sales		Profits		Taxable Income	
	(number)	(%)	($ million)	(%)	($ million)	(%)	($ million)	(%)	($ million)	(%)	($ million)	(%)
Metal mines												
Reporting corporations												
Canadian												
Private sector	119	74.8	17,589	70.3	8,671	75.9	5,943	69.9	383	119.7	94	80.3
Government	4	2.5	1,760	7.0	261	2.3	178	2.1	12	3.9	-	-
Foreign	36	22.6	5,688	22.7	2,495	21.8	2,383	28.0	-75	--	23	19.7
Total, all corporations	159	100.0	25,036	100.0	11,428	100.0	8,503	100.0	320	100.0	117	100.0
Mineral fuels												
Reporting corporations												
Canadian												
Private sector	1 483	87.5	40,002	58.8	15,155	52.4	9,727	36.3	1,226	16.1	891	16.4
Government	8	0.5	1,157	1.7	731	2.5	354	1.3	-7	--	-	-
Foreign	203	12.0	26,846	39.5	13,056	45.1	16,730	62.4	6,376	83.9	4,533	83.6
Total, all corporations	1 694	100.0	68,005	100.0	28,941	100.0	26,810	100.0	7,596	100.0	5,424	100.0
Other mining (including mining services)												
Reporting corporations												
Canadian												
Private sector	4 674	95.7	6,122	48.1	2,404	44.3	2,591	57.3	-269	259.9	129	35.0
Government	11	0.2	1,749	13.8	669	12.3	386	8.5	-36	35.0	-	-
Foreign	201	4.1	4,849	38.1	2,355	43.4	1,541	34.1	202	--	240	65.0
Total, all corporations	4 886	100.0	12,720	100.0	5,428	100.0	4,518	100.0	-103	100.0	369	100.0
Total mining												
Reporting corporations												
Canadian												
Private sector	6 276	93.1	63,713	60.2	26,230	57.3	18,260	45.8	1,341	17.2	1,114	18.8
Government	23	0.3	4,666	4.4	1,661	3.6	917	2.3	-31	--	-	-
Foreign	440	6.5	37,383	35.3	17,906	39.1	20,654	51.9	6,503	83.2	4,796	81.2
Total, all corporations	6 739	100.0	105,761	100.0	45,797	100.0	39,831	100.0	7,813	100.0	5,910	100.0

Note: Footnotes for the following table also apply to this one. Figures may not add up to totals due to rounding.

[1] Cement, lime and clay products (domestic clay) are included in mineral manufacturing.

- Nil; -- Not applicable.

TABLE 76. CANADA, FINANCIAL STATISTICS OF CORPORATIONS IN THE MINERAL MANUFACTURING INDUSTRIES[1] BY DEGREE OF NON-RESIDENT OWNERSHIP, 1983

	Corporations[2]		Assets[3]		Equity[4]		Sales[5]		Profits[6]		Taxable Income[7]	
	(number)	(%)	($ million)	(%)	($ million)	(%)	($ million)	(%)	($ million)	(%)	($ million)	(%)
Primary metal products												
Reporting corporations[2]												
Canadian												
Private sector	344	88.9	x	--	x	--	x	--	x	--	256	85.0
Government	2	0.5	x	--	x	--	x	--	x	--	-	-
Foreign	41	10.6	2,247	15.4	975	15.8	1,824	16.9	97	80.0	45	15.0
Total, all corporations	387	100.0	14,616	100.0	6,165	100.0	10,815	100.0	122	100.0	301	100.0
Nonmetallic mineral products												
Reporting corporations[2]												
Canadian												
Private sector	1 462	95.2	x	--	x	--	x	--	x	--	125	55.4
Government	4	0.3	x	--	x	--	x	--	x	--	-	-
Foreign	69	4.5	4,866	71.0	2,281	75.6	2,716	53.0	71	33.8	101	44.6
Total, all corporations	1 535	100.0	6,859	100.0	3,017	100.0	5,125	100.0	211	100.0	226	100.0
Petroleum and coal products												
Reporting corporations[2]												
Canadian												
Private sector	66	76.7	x	--	x	--	x	--	x	--	245	61.7
Government	4	4.7	x	--	x	--	x	--	x	--	-	-
Foreign	16	18.6	18,321	60.7	9,795	71.2	22,799	72.3	290	42.8	153	38.3
Total, all corporations	86	100.0	30,210	100.0	13,760	100.0	31,528	100.0	677	100.0	398	100.0
Total mineral manufacturing industries												
Reporting corporations[2]												
Canadian												
Private sector	1 872	93.2	x	--	x	--	x	--	x	--	626	67.7
Government	10	0.5	x	--	x	--	x	--	x	--	-	-
Foreign	126	6.2	25,434	49.2	13,051	56.9	27,339	57.6	458	45.3	299	32.3
Total, all corporations	2 008	100.0	51,685	100.0	22,942	100.0	47,468	100.0	1,010	100.0	925	100.0

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[1] Includes cement, lime, and clay products (domestic clay). [2] Corporations reporting under the Corporations and Labour Unions Returns Act. A corporation is considered to be foreign controlled if 50 per cent or more of its voting rights are known to be held outside Canada, and/or by one or more Canadian corporations which are, in turn, foreign controlled. Each corporation is classified according to the percentage of its voting rights which are owned by non-residents, either directly or through other Canadian corporations, and the whole of the corporation is assigned to this particular degree of foreign ownership. [3] Included are cash, marketable securities, accounts receivable, inventories, fixed assets, investments in affiliated corporations and other assets. The amounts tabulated are those shown on the balance sheets of corporations after deducting allowances for doubtful accounts, amortization, depletion and depreciation. [4] Equity represents the shareholders' interest in the net assets of the corporation and includes the total amount of all issued and paid-up share capital, earnings retained in the business and other surplus accounts such as contributed and capital surplus. [5] For nonfinancial corporations, sales are gross revenues from nonfinancial operations. For financial corporations, sales include income from financial as well as nonfinancial sources. [6] The net earnings from operations, investment income and net capital gains. Profits are tabulated after deducting allowances for amortization, depletion and depreciation, but before income tax provisions or declaration of dividends. [7] Taxable income figures are as reported by corporations prior to assessment by the Department of National Revenue. They include earnings in the reference year after the deduction of applicable losses of other years.

- Nil; -- Not applicable; x Confidential.

TABLE 77. CANADA, FINANCIAL STATISTICS OF CORPORATIONS IN NONFINANCIAL INDUSTRIES BY MAJOR INDUSTRY GROUP AND BY CONTROL, 1982 AND 1983

	Agriculture, Forestry, Fishing and Trapping		Mines, Quarries & Oil Wells		Manufacturing		Construction		Transportation, Communication and Other Utilities		Trade		Services		Total	
	1982	1983P	1982	1983P	1982	1983P	1982	1983P	1982	1983P	1982	1983P	1982	1983P	1982	1983P
								(number)								
Corporations																
Canadian control																
Private sector	21 511	21 716	6 014	6 276	36 454	36 396	61 788	60 961	22 738	22 780	163 526	171 413	115 993	117 433	390 471	392 502
Government	3	4	24	23	47	50	1	1	73	75	35	36	34	35	217	214
Foreign control	111	101	485	440	2 060	1 855	198	180	316	283	1 945	1 732	725	648	5 840	5 239
Total corporations	21 625	21 821	6 523	6 739	38 561	38 301	61 987	61 142	23 127	23 138	127 953	128 708	116 752	118 116	396 965	397 965
								($ million)								
Assets																
Canadian control																
Private sector	x	x	61,134	63,713	83,202	86,677	x	x	53,730	57,818	65,600	68,294	31,767	33,108	326,762	340,363
Government	x	x	4,866	4,666	10,942	10,200	x	x	82,747	89,778	8,467	9,275	2,343	2,425	109,373	116,354
Foreign control	455	394	33,902	37,383	76,618	77,748	2,506	2,134	5,738	5,395	16,504	17,076	6,183	6,463	141,906	146,592
Total corporations	10,752	11,130	99,902	105,761	170,762	174,625	23,546	22,162	142,215	152,992	90,571	94,645	40,293	41,995	578,041	603,309
Equity																
Canadian control																
Private sector	x	x	25,397	26,230	29,266	31,140	x	x	19,120	21,593	18,892	19,722	7,468	7,597	107,822	113,721
Government	x	x	1,884	1,661	1,814	1,142	x	x	16,387	18,233	3,733	4,366	218	243	24,041	25,672
Foreign control	142	128	15,720	17,906	36,950	39,188	841	824	1,935	1,842	5,640	6,026	2,286	2,583	63,513	68,497
Total corporations	3,365	3,504	43,001	45,797	68,030	71,469	5,300	4,895	37,442	41,667	28,264	30,134	9,972	10,423	195,375	207,889
Sales																
Canadian control																
Private sector	x	x	18,145	18,260	102,271	106,234	x	x	41,967	43,250	163,526	171,413	36,319	36,463	407,412	417,806
Government	x	x	1,025	917	5,865	7,639	x	x	20,664	22,380	12,243	12,094	1,724	1,769	41,556	44,827
Foreign control	325	275	18,706	20,654	106,031	115,341	4,510	3,467	4,172	3,807	44,200	43,746	7,506	7,623	185,450	194,913
Total corporations	8,222	8,575	37,877	39,831	214,167	229,213	41,830	37,380	66,803	69,437	219,969	227,254	45,550	45,855	634,418	657,546
Profits																
Canadian control																
Private sector	x	x	1,762	1,341	1,893	3,234	x	x	3,367	4,047	2,751	3,614	1,769	1,762	12,849	15,119
Government	x	x	-3	-31	-1,031	-259	x	x	1,340	1,578	1,701	1,862	354	373	2,366	3,525
Foreign control	27	14	4,528	6,503	4,048	5,581	160	132	461	431	618	867	702	872	10,543	14,398
Total corporations	449	359	6,287	7,813	4,910	8,556	1,049	909	5,167	6,056	5,070	6,343	2,825	3,007	25,758	33,042

Note: Figures may not add up to totals due to rounding.
P Preliminary; x Confidential.

TABLE 78. CANADA, CAPITAL AND REPAIR EXPENDITURES BY SELECTED INDUSTRIAL SECTOR, 1984-86

		Capital Expenditures			Repair Expenditures			Capital and Repair Expenditures		
		Construction	Machinery and Equipment	Total	Construction	Machinery and Equipment	Total	Construction	Machinery and Equipment	Total
						($ million)				
Agriculture	1984	1,238.7	2,940.1	4,178.8	328.9	1,148.2	1,477.1	1,567.6	4,088.3	5,655.9
	1985P	1,131.1	2,736.3	3,867.4	276.8	1,244.2	1,521.0	1,407.9	3,980.5	5,388.4
	1986^{f}	1,056.5	2,538.3	3,594.8	285.8	1,307.0	1,592.8	1,342.3	3,845.3	5,187.6
Forestry	1984	100.0	99.5	199.5	88.4	253.4	341.8	188.4	352.9	541.3
	1985P	115.2	88.0	203.2	89.3	229.2	318.5	204.5	317.2	521.7
	1986^{f}	106.9	102.0	208.9	96.0	218.0	314.0	202.9	320.0	522.9
Mining[1]	1984	8,244.3	1,631.1	9,875.4	430.2	2,025.4	2,455.6	8,674.5	3,656.5	12,331.0
	1985P	9,066.4	1,601.2	10,667.6	512.1	2,155.6	2,667.7	9,578.5	3,756.8	13,335.3
	1986^{f}	8,272.0	1,587.4	9,859.4	513.6	2,159.0	2,672.6	8,785.6	3,746.4	12,532.0
Construction	1984	207.6	1,091.7	1,299.3	28.6	833.8	862.4	236.2	1,925.5	2,161.7
	1985P	225.9	1,186.8	1,412.7	31.3	906.5	937.8	257.2	2,093.3	2,350.5
	1986^{f}	234.6	1,232.0	1,466.6	32.4	941.2	973.6	267.0	2,173.2	2,440.2
Housing	1984	12,579.9	-	12,579.9	4,067.4	-	4,067.4	16,647.3	-	16,647.3
	1985P	14,436.7	-	14,436.7	4,313.4	-	4,313.4	18,750.1	-	18,750.1
	1986^{f}	16,600.4	-	16,600.4	4,576.8	-	4,576.8	21,177.2	-	21,177.2
Manufacturing	1984	1,823.5	7,063.2	8,886.7	918.3	4,829.6	5,747.9	2,741.8	11,892.8	14,634.6
	1985P	2,200.3	8,803.2	11,003.5	962.9	5,095.5	6,058.4	3,163.2	13,898.7	17,061.9
	1986^{f}	2,449.1	10,438.0	12,887.1	1,011.8	5,280.2	6,292.0	3,460.9	15,718.2	19,179.1
Utilities	1984	7,235.5	7,052.8	14,288.3	1,842.9	4,762.7	6,605.6	9,078.4	11,815.5	20,893.9
	1985P	6,815.4	6,735.3	13,550.7	1,933.0	5,029.8	6,962.8	8,748.4	11,765.1	20,513.5
	1986^{f}	6,673.2	6,634.0	13,307.2	2,029.8	5,136.4	7,166.2	8,703.0	11,770.4	20,473.4
Trade	1984	708.5	1,777.3	2,485.8	288.9	325.1	614.0	997.4	2,102.4	3,099.8
	1985P	676.2	1,655.8	2,332.0	253.3	296.1	549.4	929.5	1,951.9	2,881.4
	1986^{f}	740.9	1,704.7	2,445.6	253.5	306.8	560.3	994.4	2,011.5	3,005.9
Other[2]	1984	13,631.6	7,952.3	21,583.9	2,809.3	1,344.8	4,154.1	16,440.9	9,297.1	25,738.0
	1985P	15,529.7	9,087.1	24,616.8	2,879.8	1,447.6	4,327.4	18,409.5	10,534.7	28,944.2
	1986^{f}	15,909.5	9,572.2	25,481.7	2,978.9	1,565.8	4,544.7	18,888.4	11,138.0	30,026.4
Total	1984	45,769.6	29,608.0	75,377.6	10,802.9	15,523.0	26,325.9	56,572.5	45,131.0	101,703.5
	1985P	50,196.9	31,893.7	82,090.6	11,251.9	16,404.5	27,656.4	61,448.8	48,298.2	109,747.0
	1986^{f}	52,043.1	33,808.6	85,851.7	11,778.6	16,914.4	28,693.0	63,821.7	50,723.0	114,544.7
Mining as a percentage of total	1984	18.0	5.5	13.1	4.0	13.0	9.3	15.3	8.1	12.1
	1985P	18.1	5.0	13.0	4.5	13.1	9.6	15.6	7.8	12.2
	1986^{f}	15.9	5.0	11.5	4.4	12.8	9.3	13.8	7.4	10.9

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[1] Includes mines, quarries and oil wells. [2] Includes finance, real estate, insurance, commercial services, institutions and government departments.
P Preliminary; ^{f} Forecast; - Nil.

TABLE 79. CANADA, CAPITAL AND REPAIR EXPENDITURES IN MINING[1] BY GEOGRAPHICAL REGION, 1984-86

		Capital Expenditures			Repair Expenditures			Capital and Repair Expenditures		
		Construction	Machinery and Equipment	Total	Construction	Machinery and Equipment	Total	Construction	Machinery and Equipment	Total
		($ million)								
Atlantic Region	1984	1,540.6	211.8	1,752.4	13.8	165.9	179.7	1,554.4	377.7	1,932.1
	1985^p	1,477.7	225.4	1,703.1	15.5	180.2	195.7	1,493.2	405.6	1,898.8
	1986^f	779.1	146.8	925.9	16.3	179.9	196.2	795.4	326.7	1,122.1
Quebec	1984	246.1	70.7	316.8	26.8	167.2	194.0	272.9	237.9	510.8
	1985^p	278.9	81.4	360.3	21.9	210.3	232.2	300.8	291.7	592.5
	1986^f	257.1	85.8	342.9	24.0	204.6	228.6	281.1	290.4	571.5
Ontario	1984	392.4	163.1	555.5	51.9	329.2	381.1	444.3	492.3	936.6
	1985^p	448.2	171.6	619.8	49.1	338.9	388.0	497.3	510.5	1,007.8
	1986^f	377.6	172.8	550.4	49.9	335.1	385.0	427.5	507.9	935.4
Prairie Region	1984	4,285.2	930.4	5,215.6	285.5	905.3	1,190.8	4,570.7	1,835.7	6,406.4
	1985^p	5,360.7	975.9	6,336.6	369.1	982.9	1,352.0	5,729.8	1,958.8	7,688.6
	1986^f	5,748.4	1,019.0	6,767.4	368.1	968.9	1,337.0	6,116.5	1,987.9	8,104.4
British Columbia	1984	648.0	160.2	808.2	42.2	362.3	404.5	690.2	522.5	1,212.7
	1985^p	459.7	110.3	570.0	42.1	359.8	401.9	501.8	470.1	971.9
	1986^f	401.8	109.5	511.3	44.3	388.9	433.2	446.1	498.4	944.5
Yukon and Northwest Territories	1984	1,132.0	94.9	1,226.9	10.0	95.5	105.5	1,142.0	190.4	1,332.4
	1985^p	1,041.2	36.6	1,077.8	14.4	83.5	97.9	1,055.6	120.1	1,175.7
	1986^f	708.0	53.5	761.5	11.0	81.6	92.6	719.0	135.1	854.1
Canada, total	1984	8,244.3	1,631.1	9,875.4	430.2	2,025.4	2,455.6	8,674.5	3,656.5	12,331.0
	1985^p	9,066.4	1,601.2	10,667.6	512.1	2,155.6	2,667.7	9,578.5	3,756.8	13,335.3
	1986^f	8,272.0	1,587.4	9,859.4	513.6	2,159.0	2,672.6	8,785.6	3,746.4	12,532.0

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[1] Includes mines, quarries and oil wells.
^{p} Preliminary; ^{f} Forecast.

TABLE 88. CANADA, CAPITAL AND REPAIR EXPENDITURES IN MINING[1] AND MINERAL MANUFACTURING INDUSTRIES, 1984-86

	1984			1985P			1986f		
	Capital	Repair	Total	Capital	Repair	Total	Capital	Repair	Total
					($ million)				
Mining industry									
Metal mines									
Gold	501.6	98.5	600.1	470.2	109.8	580.0	389.3	120.5	509.8
Silver-lead-zinc	86.6	120.1	206.7	84.8	96.7	181.5	55.9	97.5	153.4
Copper-gold-silver	268.0	278.8	546.8	244.4	216.7	461.1	221.8	236.1	457.9
Iron	90.5	187.9	278.4	97.3	214.5	311.8	113.7	202.2	315.9
Other metal mines	368.2	275.4	643.6	438.1	295.9	734.0	349.5	298.5	648.0
Total metal mines	1,314.9	960.7	2,275.6	1,334.8	933.6	2,268.4	1,130.2	954.8	2,085.0
Nonmetal mines									
Asbestos	35.1	51.5	86.6	28.8	54.7	83.5	25.5	47.4	72.9
Other nonmetal mines[2]	1,195.2	450.5	1,645.7	782.8	516.8	1,299.6	578.8	503.9	1,082.7
Total nonmetal mines	1,230.3	502.0	1,732.3	811.6	571.5	1,383.1	604.3	551.3	1,155.6
Mineral fuels									
Oil, crude and gas[3]	7,330.2	992.9	8,323.1	8,521.2	1,162.6	9,683.8	8,124.9	1,166.5	9,291.4
Total mining industries	9,875.4	2,455.6	12,331.0	10,667.6	2,667.7	13,335.3	9,859.4	2,672.6	12,532.0
Mineral manufacturing									
Primary metal industries									
Iron and steel mills	189.9	801.9	991.8	424.1	761.2	1,185.3	661.1	790.6	1,451.7
Steel pipe and tube mills	34.7	63.2	97.9	121.5	69.2	190.7	x	76.2	x
Iron foundries	43.9	44.9	88.8	40.0	54.5	94.5	x	60.5	x
Smelting and refining	692.8	355.8	1,048.6	832.2	361.0	1,193.2	568.4	360.5	928.9
Aluminum rolling, casting and extruding	42.7	45.8	88.5	50.3	54.9	105.2	61.3	58.2	119.5
Copper and copper alloy, rolling, casting and extruding	8.9	7.4	16.3	7.3	8.3	15.6	8.4	8.3	16.7
Metal rolling, casting and extruding	18.3	16.3	34.6	24.2	16.2	40.4	15.0	16.3	31.3
Total primary metal industries	1,031.2	1,335.3	2,366.5	1,499.6	1,325.3	2,824.9	1,508.1	1,370.6	2,878.7
Nonmetallic mineral products									
Cement	15.4	64.6	80.0	31.5	71.8	103.3	36.6	77.2	113.8
Stone products	4.6	1.0	5.6	0.7	0.7	1.4	0.8	1.1	1.9
Concrete products	18.9	25.9	44.8	26.8	25.2	52.0	26.8	22.0	48.8
Ready-mix concrete	20.3	59.6	79.9	32.2	63.6	95.8	31.7	66.5	98.2
Clay products	5.2	8.6	13.8	5.4	6.6	12.0	22.3	8.6	30.9
Glass and glass products	56.4	32.5	88.9	88.2	37.1	125.3	92.2	32.6	124.8
Abrasives	9.1	13.1	22.2	8.8	13.3	22.1	4.9	12.6	17.5
Lime	4.9	7.6	12.5	1.8	8.2	10.0	4.9	8.7	13.6
Other nonmetallic mineral products	42.8	49.9	92.7	38.4	57.4	95.8	51.1	59.9	111.0
Total nonmetallic mineral products	177.6	262.8	440.4	233.8	283.9	517.7	271.3	289.2	560.5
Petroleum and coal products	432.4	309.6	742.0	287.5	316.2	603.7	351.0	338.5	689.5
Total mineral manufacturing industries	1,641.2	1,907.7	3,548.9	2,020.9	1,925.4	3,946.3	2,130.4	1,998.3	4,128.7
Total mining and mineral manufacturing industries	11,516.6	4,363.3	15,879.9	12,688.5	4,593.1	17,281.6	11,989.8	4,670.9	16,660.7

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[1] Does not include cement, lime and clay products (domestic clay) manufacturing, smelting and refining. [2] Includes coal mines, gypsum, salt, potash and miscellaneous nonmetal mines and quarrying. [3] The total of capital expenditures shown under "petroleum and gas" is equal to the total capital expenditure under the column entitled "petroleum and natural gas extraction" and under the column "natural gas processing plants" of Table 83.

P Preliminary; f Forecast; x Confidential.

TABLE 81. CANADA, CAPITAL AND REPAIR EXPENDITURES IN THE MINING INDUSTRY[1], 1980-86

	1980	1981	1982	1983	1984	1985P	1986f
				($ million)			
Metal mines							
Capital							
Construction	1,109.1	1,331.3	1,099.4	839.1	942.2	930.4	764.6
Machinery	467.2	576.4	370.6	312.0	372.7	404.4	365.6
Total	1,576.3	1,907.7	1,470.0	1,151.1	1,314.9	1,334.8	1,130.3
Repair							
Construction	137.3	151.9	112.4	93.3	99.6	90.4	94.5
Machinery	767.7	900.8	805.1	728.0	861.1	843.2	860.3
Total	905.0	1,052.7	917.5	821.3	960.7	933.6	954.8
Total capital and repair	2,481.3	2,960.4	2,387.5	1,972.4	2,275.6	2,268.4	2,085.0
Nonmetal mines[2]							
Capital							
Construction	346.4	647.8	888.6	1,123.3	658.6	437.9	280.3
Machinery	267.6	417.7	563.3	433.9	571.7	373.7	324.0
Total	614.0	1,065.5	1,451.9	1,557.2	1,230.3	811.6	604.3
Repair							
Construction	32.5	26.0	28.6	25.5	47.2	35.7	35.8
Machinery	393.1	447.8	431.8	401.5	454.8	535.8	515.5
Total	425.6	473.8	460.4	427.0	502.0	571.5	551.3
Total capital and repair	1,039.6	1,539.3	1,912.3	1,984.2	1,732.3	1,383.1	1,155.6
Mineral fuels							
Capital							
Construction	5,453.1	5,825.1	6,019.2	6,034.1	6,643.5	7,698.1	7,227.1
Machinery	800.3	1,206.3	1,420.5	880.6	686.7	823.1	897.8
Total	6,253.4	7,031.4	7,439.7	6,914.7	7,330.2	8,521.2	8,124.9
Repair							
Construction	627.6	514.4	484.4	427.4	283.4	386.0	383.3
Machinery	313.6	639.0	698.3	656.7	709.5	776.6	783.2
Total	941.2	1,153.4	1,182.7	1,084.1	992.9	1,162.6	1,166.5
Total capital and repair	7,194.6	8,184.8	8,622.4	7,998.8	8,323.1	9,683.8	9,291.4
Total mining							
Capital							
Construction	6,908.6	7,804.2	8,007.2	7,996.5	8,244.3	9,066.4	8,272.0
Machinery	1,535.1	2,200.4	2,354.4	1,626.5	1,631.1	1,601.2	1,587.4
Total	8,443.7	10,004.6	10,361.6	9,623.0	9,875.4	10,667.6	9,859.4
Repair							
Construction	797.4	692.5	625.4	546.2	430.2	512.1	513.6
Machinery	1,474.4	1,987.6	1,935.2	1,786.2	2,025.4	2,155.6	2,159.0
Total	2,271.8	2,680.1	2,560.6	2,332.4	2,455.6	2,667.7	2,672.6
Total capital and repair	10,715.5	12,684.7	12,922.2	11,955.4	12,331.0	13,335.3	12,532.0

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[1] Does not include cement, lime and clay products (domestic clays) manufacturing, smelting and refining. [2] Includes coal mines, asbestos, gypsum, salt, potash, miscellaneous nonmetals, quarrying and sand pits.

P Preliminary; f Forecast.

TABLE 82. CANADA, CAPITAL AND REPAIR EXPENDITURES IN THE MINERAL MANUFACTURING INDUSTRIES, 1980-86

	1980	1981	1982	1983	1984	1985P	1986f
				($ million)			
Primary metal industries[1]							
Capital							
Construction	328.2	330.1	278.3	112.5	318.6	426.9	333.3
Machinery	960.9	1,289.6	927.5	550.6	712.6	1,072.7	1,174.8
Total	1,289.1	1,619.7	1,205.8	663.1	1,031.2	1,499.6	1,508.1
Repair							
Construction	122.1	139.0	99.2	111.4	119.6	124.0	129.1
Machinery	998.5	1,053.3	1,021.6	1,053.1	1,215.7	1,201.3	1,241.5
Total	1,120.6	1,192.3	1,120.8	1,164.5	1,335.3	1,325.3	1,370.6
Total capital and repair	2,409.7	2,812.0	2,326.6	1,827.6	2,366.5	2,824.9	2,878.7
Nonmetallic mineral products[2]							
Capital							
Construction	70.0	93.4	32.0	14.8	26.6	30.4	30.4
Machinery	249.7	254.0	134.4	125.5	151.0	203.4	240.9
Total	319.7	347.4	166.4	140.3	177.6	233.8	271.3
Repair							
Construction	16.7	23.7	20.7	20.7	26.3	25.9	30.2
Machinery	213.8	227.5	211.1	204.1	236.5	258.0	259.0
Total	230.5	251.2	231.8	224.8	262.8	283.9	226.3
Total capital and repair	550.2	598.6	398.2	365.1	440.4	517.7	560.5
Petroleum and coal products							
Capital							
Construction	215.6	629.9	890.8	629.6	321.4	213.5	262.6
Machinery	109.1	215.0	333.7	211.2	111.0	74.0	88.4
Total	324.7	844.9	1,224.5	840.8	432.4	287.5	351.0
Repair							
Construction	190.5	212.9	218.5	196.0	230.3	231.9	250.8
Machinery	76.2	89.1	101.2	68.6	79.3	84.3	87.7
Total	266.7	302.0	319.7	264.6	309.6	316.[illegible]	338.5
Total capital and repair	591.4	1,146.9	1,544.2	1,105.4	742.0	603.7	689.5
Total mineral manufacturing industries							
Capital							
Construction	613.8	1,053.4	1,201.1	756.9	666.6	670.8	626.3
Machinery	1,319.7	1,758.6	1,395.6	887.3	974.6	1,350.1	1,504.1
Total	1,933.5	2,812.0	2,596.7	1,644.2	1,641.2	2,020.9	2,130.4
Repair							
Construction	329.3	375.6	338.4	328.1	376.2	381.8	410.1
Machinery	1,288.5	1,369.9	1,333.9	1,328.1	1,531.5	1,543.6	1,588.2
Total	1,617.8	1,745.5	1,672.3	1,653.9	1,907.7	1,925.4	1,998.3
Total capital and repair	3,551.3	4,557.5	4,269.0	3,298.1	3,548.9	3,946.3	4,128.7

[1] Includes smelting and refining. [2] Includes cement, lime and clay products manufacturing.
P Preliminary; f Forecast.

TABLE 83. CANADA, CAPITAL EXPENDITURES IN THE PETROLEUM, NATURAL GAS AND ALLIED INDUSTRIES[1], 1980-86

	Petroleum and Natural Gas Extraction	Transportation Including Rail, Water and Pipelines	Marketing (Chiefly Outlets of Oil Companies)	Natural Gas Distribution	Petroleum and Coal Products Industries	Natural Gas Processing Plants	Oil and Gas Drilling Contractors	Total Capital Expenditures
				($ million)				
1980	5,744.2	602.1	205.2	386.4	324.7	311.5	197.7	7,771.8
1981	6,444.9	1,745.7	264.1	408.7	844.9	311.6	274.9	10,294.8
1982	6,743.4	1,994.3	320.5	517.6	1,224.5	522.8	173.5	11,496.6
1983	6,563.5	660.5	374.5	516.8	840.8	195.8	155.4	9,307.3
1984	6,946.4	795.4	422.9	604.1	432.4	340.0	43.8	9,585.0
1985P	8,135.4	623.4	352.5	559.6	287.5	331.4	54.4	10,344.2
1986f	7,824.9	620.4	388.3	514.3	351.0	274.3	25.7	9,998.9

[1] The petroleum and natural gas industries in this table include all companies engaged in whole or in part in oil and gas activities.
P Preliminary; f Forecast.

TABLE 84. CANADA, TOTAL INTRAMURAL RESEARCH AND DEVELOPMENT EXPENDITURES FOR MINING-RELATED INDUSTRIES IN CURRENT AND CONSTANT (1977) DOLLARS, 1980-86

	1980	1981	1982	1983	1984	1985P	1986f
				($ million)			
Current dollars							
Mining industry	101	131	132	92	114	137	129
Mines	28	51	48	45	49	54	52
Oil and gas wells	72	80	84	48	65	84	77
Mineral manufacturing	275	391	362	297	301	342	359
Ferrous primary metals	21	24	23	21	28	27	28
Nonferrous primary metals	85	86	86	82	95	103	110
Nonmetallic mineral products	8	9	9	10	16	19	16
Petroleum products	161	272	244	184	162	193	205
Constant dollars							
Mining industry	77	90	83	55	66	77	71
Mines	22	35	30	27	28	30	29
Oil and gas wells	55	55	53	28	37	47	42
Mineral manufacturing	210	270	228	177	174	192	197
Ferrous primary metals	16	16	15	13	16	15	15
Nonferrous primary metals	65	60	54	49	55	58	60
Nonmetallic mineral products	6	6	6	6	9	11	9
Petroleum products	123	188	153	109	94	108	113

P Preliminary; f Forecast.

TABLE 85. CANADA, CURRENT AND CAPITAL INTRAMURAL RESEARCH AND DEVELOPMENT EXPENDITURES FOR MINING-RELATED INDUSTRIES, 1980-86

	1980	1981	1982	1983	1984	1985P	1986[f]
				($ million)			
Capital expenditures							
Mining industry	33	38	36	21	21	40	29
Mines	3	3	4	6	7	8	6
Oil and gas wells	30	34	33	15	14	32	24
Mineral manufacturing	61	59	81	48	43	42	37
Ferrous primary metals	1	2	1	1	1	2	1
Nonferrous primary metals	24	17	10	5	9	6	5
Nonmetallic mineral products	1	1	1	1	5	6	2
Petroleum products	35	39	69	41	28	28	29
Current expenditures							
Mining industry	67	93	96	71	93	97	100
Mines	25	48	44	39	43	45	47
Oil and gas wells	42	46	52	33	50	52	53
Mineral manufacturing	214	333	281	250	258	299	321
Ferrous primary metals	20	22	22	21	27	25	26
Nonferrous primary metals	61	70	76	77	86	97	105
Nonmetallic mineral products	7	8	8	9	11	13	14
Petroleum products	126	233	175	143	134	164	176
Total expenditures							
Mining industry	101	131	132	92	114	137	129
Mines	28	51	48	45	49	54	52
Oil and gas wells	72	80	84	48	65	84	77
Mineral manufacturing	275	391	362	297	301	342	359
Ferrous primary metals	21	24	23	21	28	27	28
Nonferrous primary metals	85	86	86	82	95	103	110
Nonmetallic mineral products	8	9	9	10	16	19	16
Petroleum products	161	272	244	184	162	193	205

P Preliminary; [f] Forecast.